

**OPERATION AND MAINTENANCE MANUAL
DELATTE METALS SUPERFUND SITE
PONCHATOULA, TANGIPAHOA PARISH, LOUISIANA
EPA ID NO. LAD052510344
LDEQ AGENCY INTEREST NO. 2328**

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ACRONYMS AND ABBREVIATIONS

COC	Chain-of-custody
Delatte	Delatte Metals Superfund Site
EPA	U.S. Environmental Protection Agency
ETD	Environmental Technology Division
HASP	Health and safety plan
HNO ₃	Nitric acid
LDEQ	Louisiana Department of Environmental Quality
MCL	Maximum contaminant level
MS/MD	Matrix spike/matrix duplicate
F m	Micrometer
NTU	Nephelometric turbidity units
O&M	Operation and maintenance
OEA	Office of Environmental Assessment
PPE	Personal protective equipment
PRB	Permeable reactive barrier wall
QA	Quality assurance
QC	Quality control
RA	remedial action
SOP	Standard operating procedure
Tetra Tech	Tetra Tech EM Inc.
WBZ	Water-bearing zone

1.0 INTRODUCTION

This operation and maintenance (O&M) manual was prepared for the U.S. Environmental Protection Agency (EPA) for use at the Delatte Metals (Delatte) Superfund Site located in Ponchatoula, Tangipahoa Parish, Louisiana. The Louisiana Department of Environmental Quality (LDEQ) official site name is Delatte Metals site, Agency Interest No. 2328. The EPA official site name is "Delatte Metals Superfund Site," EPA No. LAD052510344. This O&M Manual was revised by the LDEQ Office of Environmental Assessment / Environmental Technology Division (OEA/ETD) in May of 2004 due to minor agency policy differences and due to changes in scope regarding the plugging and abandoning of wells since development of the original O&M Manual.

As described in the Record of Decision, the remedial action (RA) was to address the contamination in the soil, sediment, surface water, and ground water at the site by:

- Immobilization to address the principal threat wastes in the soil (thus eliminating the source of contamination for sediment, surface water, and ground water);
- Off-site disposal to transport immobilized wastes to a disposal facility;
- Installation of permeable reactive barrier walls (PRB) to neutralize the acidity of the shallow ground water and limit the migration of dissolved metals;
- Implementation of institutional controls in the form of deed notices to inform the public of site conditions; and
- Ground water monitoring to ensure the effectiveness of the selected remedy.

During the RA, the principal threat wastes in the soil were excavated, immobilized, and transported off-site for disposal, and a permeable treatment wall was installed to neutralize the acidity of the shallow ground water and limit the migration of dissolved metals. However, the site was not restored to levels that allow for unlimited use and unrestricted exposure.

The Comprehensive Environmental Response, Compensation, and Liability Act Section (§§)121(c), as amended, states the following:

"If the President selects a remedial action that results in any hazardous substances, pollutants, or

contaminants remaining at the site, the President shall review such remedial action no less often than each five years after the initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented."

The National Oil and Hazardous Substance Pollution Contingency Plan §300.430(f)(4)(ii) states the following:

"If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after the initiation of the selected remedial action."

The purpose of the O&M manual is to describe the actions needed to verify that the institutional controls are in place and to describe the ground water monitoring program used to ensure the effectiveness of the remedy. As part of the RA, EPA will monitor the wells at the site for a period of one year after construction completion. The purpose of this monitoring is to ensure that the monitoring wells are functioning properly, that the PRB was constructed properly, and that baseline water quality conditions are established via monitoring. Ground water downgradient of the PRB will be monitored to verify that the pH is increasing and that the metals concentrations are decreasing. The third water-bearing zone (WBZ) will be monitored to ensure that no downward migration occurs. On September 22, 2004, one year after construction completion, the RA report will be finalized and O&M will begin under the State of Louisiana, through the Department of Environmental Quality.

This manual describes the long-term O&M activities that will be required at the Delatte site in order to ensure the effectiveness, protectiveness, and integrity of the remedy. This O&M manual includes: (1) safety requirements, (2) monitoring program, and (3) routine maintenance and inspection procedures. To the extent practicable, routine O&M and sampling activities will be performed following standard operating procedures (SOP) that have been developed as part of the RA quality assurance (QA) program (Appendix B). Use of SOPs will help ensure that data collected is reproducible and technically defensible.

The O&M manual is divided into five chapters. Section 1.0 provides an introduction and general

overview of the O&M manual. Section 2.0 describes general health and safety information. Section 3.0 discusses the ground water monitoring program. Section 4.0 describes routine maintenance and inspection activities to be completed. Section 5.0 describes the reporting. The references used in this O&M manual are listed in Section 6.0.

Appendix A formerly included a Health and Safety Plan (H&SP); however, refer to the LDEQ Specifications document requiring health and safety requirements. Appendix B includes SOPs pertaining to activities that will take place during the O&M period at the Delatte site. Appendix C includes tables. Appendix D includes a site figure. Appendix E includes information pertaining to trend analyses for intrawell comparisons. Appendix F includes contact information for landowners (this information is not provided in this report due to the presence of private personal data).

2.0 HEALTH AND SAFETY

O&M activities and physical features of the site may expose field personnel to a variety of hazards. All personnel involved in the routine on-site O&M activities must receive training in accordance with Occupational Safety and Health Administration 1910.120, including 40-hour initial Hazardous Waste Site Worker certification with a current 8-hour annual refresher. Refer to the LDEQ Bid Specifications document for information regarding health and safety requirements.

Physical hazards associated with O&M activities may pose a threat to on-site personnel. Dangers may include heavy equipment, slippery surfaces, unseen obstacles, noise, heat, cold, snake bites, and poor illumination. Injuries may result, for example, from the following:

- Accidents caused by slips, trips, or falls
- Use of improper lifting techniques
- Use of moving or rotating equipment
- Equipment mobilization and operation
- Use of improperly maintained equipment

Injuries resulting from physical hazards can be avoided by using safe work practices and employing

caution when working with machinery. Physical hazards that have been identified at this site include the following:

- Slips, trips, and falls
- Moving equipment
- Noise
- Lifting and carrying
- Biological hazards

Appropriate personal protective equipment (PPE) should be worn while performing O&M duties at the Delatte site.

3.0 MONITORING PROGRAM

In order to ensure the effectiveness, protectiveness, and integrity of the remedy, long-term monitoring activities at the Delatte site will include sampling to determine that the ground water pH downgradient of the PRB is increasing, that metals concentrations in the ground water downgradient of the PRB are decreasing, and that the metals concentrations in the ground water of the third WBZ are not increasing. Metals that will be sampled were identified during the site investigation and include arsenic, lead, manganese, nickel, and thallium. This section describes the procedures for collecting ground water samples from the on- and off-facility monitoring wells, the on-facility water wells, and nearby off-facility water wells.

3.1 SAMPLING ACTIVITIES

A total of 30 on- and off-facility monitoring wells and water wells will be sampled as part of this monitoring program. Of these, 9 wells are screened in the first WBZ, 13 wells are screened in the second WBZ, 4 wells are screened in the third WBZ, and 4 wells are water-supply wells. The monitoring well locations are shown on Appendix D, Figure 1. Construction details are summarized in Appendix C, Table 1 (Appendix C). Of the four wells that are water supply wells, there are two on-facility water wells and

two nearby off-facility water wells. Details regarding the water wells are listed in, Table 2 (Appendix C).

Additional wells and piezometers installed by EPA Robert S. Kerr Environmental Research Center in and around the PRB will be sampled separately by EPA and are not included in this O&M manual.

Before sampling activities begin, the appropriate landowners will be contacted by LDEQ to inform them of the activities on their respective properties. Current landowner contacts are included in Appendix F. All on-facility monitoring wells will be sampled using low-flow sampling techniques in an effort to (1) obtain samples that are representative of the mobile load of contaminants present, (2) to minimize disturbance of the sampling point thereby minimizing sampling artifacts, (3) minimize sampling variability between sampling events, (4) minimize drawdown, (5) minimize casing water mixing, (6) minimize the need for filtration, and (7) reduce pumping volume.

The samples will be analyzed for total metals when the turbidity measurements stabilize below 10 nephelometric turbidity units (NTU). If water quality parameters have stabilized within the allowable variances and the turbidity is above 10 NTU, the sampling team will collect a total and dissolved metals sample. Samples analyzed for total metals will not be filtered; however, the dissolved metals samples will be filtered in the field using a 0.45-micrometer [μm] membrane filter. The ground water pH measurements as well as the turbidity measurements will be measured in the field.

Any data set evaluated for trends over time will have at least eight time-independent data points and a minimum detection rate of 50 percent (EPA 2000). As the number of observations grows over time, so does the certainty of observed trends. Therefore, in order to perform statistical data analysis, quarterly monitoring of the well network will be required to obtain at least eight time-independent data points. Ground water data collected during the last year of RA and the first year of O&M will be evaluated using statistical tools to quantitatively assess metals concentrations and pH. Intra-well trends and population trends (upgradient and downgradient) in metals concentrations and pH will be used to evaluate the efficacy of the remedy and to recommend changes to the monitoring program, as necessary.

3.2 QUALITY ASSURANCE ACTIVITIES

This section addresses the requirements for consistent collection of quality ground water samples and data. Various SOPs are included in Appendix B.

3.2.1 Sample, Container, Volume, Preservation, and Holding Time Requirements

A representative fraction of ground water from each well shall be placed directly into containers. A one 1-liter polyethylene container preserved with nitric acid (HNO_3) will be used for total metals analysis. If the turbidity remains above 10 NTU after water quality parameters have stabilized, then a disposable 0.45- μm inline filter will be installed in the line and a filtered sample will also be collected in a 1-L polyethylene container preserved with HNO_3 for dissolved metals analysis. Sample containers will be sealed to prevent leakage and then stored in an ice chest at 4 °C. Table 3 (Appendix C) summarizes the required sample types, volumes, preservation, and holding time requirements.

3.2.2 Sampling Methods

Sampling methods and equipment have been selected to meet project objectives. The sampling team shall use EPA-approved methods for sample collection and field measurements. All monitoring wells will be sampled using a low-flow or micropurging technique outlined in SOP No. 15, included in Appendix B.

Prior to sampling, monitoring wells will be unlocked and uncapped by site personnel to allow them to vent for a minimum of 15 minutes. The sampling team will use a water level indicator to determine the static water level and total depth of the well. All monitoring wells will be sampled using a low-flow or micropurging technique. Water quality parameters including temperature, pH, conductivity, turbidity, oxidation-reduction potential, and dissolved oxygen will be taken in the field using a flow-through cell and allowed stabilize to within the criteria outlined in SOP No. 15. The flow-through cell will be used in order to allow regular or continuous measurements and minimize contact between the water and air. As the water moves through the flow-through cell, readings will be taken every 3 minutes and the well pH value determined after pH has stabilized. The pH will be stable when a fluctuation of ± 0.1 pH unit is obtained from three successive readings. If water quality parameters have stabilized within the allowable variances and the turbidity is below 10 NTU, the sampling team will collect a total metals sample. If

water quality parameters have stabilized within the allowable variances and the turbidity is above 10 NTU, the sampling team will collect total and dissolved metals samples. If the recharge rate is so slow that even low flow cannot be maintained, the respective wells will be purged dry and sampled within 24 hours of being purged dry.

The on- and off-facility water supply wells will be sampled by opening existing valves and allowing the water to run for a minimum of 15 minutes. At this time, a sample will be collected in a 1-L plastic container preserved with HNO₃. If the wells are not operational for any reason, these water supply wells will not be sampled.

Following purging and sampling, solid investigation-derived waste materials will be placed in trash bags and disposed of as solid waste. Water purged from the monitoring wells will be collected in closed-top 55-gallon drums. Following each sampling event and receipt of the sampling results, the Contractor shall be responsible for removing and disposing of the water in accordance with federal and state regulations.

The sampling team will be responsible for addressing failures in the sampling or measurement systems and will implement corrective action in these situations. In general, corrective action for field sampling and measurement failures include recalibration of instruments, replacement of malfunctioning measurement instruments or sampling equipment, and resampling or repetition of measurements.

3.2.3 Sample Handling and Custody Requirements

Each sample collected will be traceable from the point of collection through analysis and final disposition to ensure sample integrity. Sample integrity helps to ensure the legal defensibility of the analytical data and subsequent conclusions. The sampling team will use standard EPA procedures to identify, track, monitor, and maintain chain-of-custody (COC) for all samples. These procedures include the following:

- Field COC procedures
- Field procedures
- Field logbooks
- Laboratory COC procedures

3.2.4 Laboratory Analytical Methods

Laboratory analyses of field samples will be conducted by a laboratory capable of analyzing for site metals in ground water. The laboratory will use analytical methods and standards presented in the contract-laboratory program statements of work. The analytical methods are summarized in Table 3 (Appendix C). In all cases, appropriate methods of sample preparation, cleanup, and analyses are based on specific analytical parameters of interest, sample matrices, and required detection limits. Note: Refer to the LDEQ Bid Specifications document regarding laboratory accreditation.

3.2.5 Quality Control Requirements

Field and laboratory quality control (QC) samples and measurements will be used to verify that analytical data meet QA objectives. Field QC samples and measurements will be used to assess the influence of sampling activities and measurements on data quality. Laboratory QC samples will be used to assess the influence of a laboratory's analytical program on data quality. The field and QC requirements for samples provide definitions and typical collection and analysis frequencies of common field and laboratory QC samples and measurements. They also outline the procedures used to assess field measurements, laboratory data, and common data quality indicators.

Field duplicate samples are independent samples collected as close as possible, in space and time, to the original sample. Immediately following collection of the original sample, the field duplicate sample is collected by using the same collection method. Field duplicate samples can measure the influence of sampling and field procedures on the precision of an environmental measurement. Field duplicates should be collected at a frequency of one for every 10 samples collected.

Matrix spike/matrix duplicate (MS/MD) samples are laboratory QC samples that are collected in the field. For aqueous samples, MS/MD samples require two times the normal volume for inorganic analysis. Analytical results of the MS/MD samples are used to measure the accuracy of the inorganic analytical program. One MS/MD sample should be analyzed for every 20 ground water samples collected.

3.2.6 Data Management

Data for this project will be obtained from a number of sources, including field measurements and subcontracted laboratories. The data gathering process requires a coordinated effort and will be conducted by the Contractor's project staff members in conjunction with all potential data producers. The data will be obtained from the analytical service provider, when appropriate, in the form of an electronic data deliverable, in addition to the required hard copy analytical data package. Third party validation of data will be conducted before associated results are presented or are used in subsequent activities. See the LDEQ Bid Special Terms and Conditions for analytical data validator requirements.

Data tracking is essential to ensure timely, cost-effective, and high-quality results. Data tracking begins with sample COC. When the analytical services provider receives custody of the samples, the provider will send a sample acknowledgment to the Contractor's project team. The sample acknowledgment will confirm sample receipt, condition, and required analyses. The tracking program will contain all pertinent information about each sample and can track the data at each phase of the process. The tracking program carries the data through completion of the data validation.

Ten percent (10%) of the analytical data shall be validated to ensure that the confirmatory data are accurate and defensible. As a part of the data validation process, the electronic data deliverables will be reviewed against the hard copy deliverables to ensure the accurate transfer of data. In addition, the hard copy will be evaluated for errors in the calculation of results. After the data validation, qualifiers can be placed on the data to indicate the usability of the data. These qualifiers will be placed into the electronic data file. Upon approval of the data set with the appropriate data qualifiers, the electronic data will be released to the Contractor's project manager for reporting.

3.3 DATA ANALYSIS AND STATISTICAL TESTING

Ground water data collected during the monitoring program will be evaluated using statistical tools to quantitatively assess metals and pH concentrations in ground water. The Contractor shall conduct the statistical analysis at the completion of the second year (last year of RA and the first year of O&M) of sampling when at least 8 time-independent data points at a minimum detection rate of 50 percent (EPA 2000) have been obtained. Intra-well trends and population trends (upgradient and downgradient) in

metals concentrations and pH will be used to evaluate the efficacy of the remedy and to recommend changes to the monitoring program, as necessary. The following sections discuss data preparation, tests for trends, statistical tests comparing site data against cleanup levels, and statistical tests comparing upgradient and downgradient concentrations.

3.3.1 Data Preparation

All data sets will be screened for rejected records ("R" qualified data), and these data will be excluded from the working data sets (Appendix E). Statistical quantities for metals with nondetected results ("U" qualified data) will be calculated using one-half the reporting limit as a substituted value for the nondetected result. This simple substitution provides a reasonable approximation of summary statistics if the detection rate is 85 percent or greater (EPA 2000). Other methods of substitution are recommended for metals with detection rates less than 85 percent but greater than 50 percent; however, although EPA provides guidelines for handling nondetect data (EPA 2000), it recognizes that no general procedures are applicable in all cases.

Descriptive summary statistics will be calculated after 2 years (8 quarters) of sample data have been collected. Data sets will also be evaluated for distribution and outliers using statistical plots and/or statistical tests for distribution, (such as the Shapiro-Wilk test), and for outliers (such as the Rosner test).

Data may be grouped by well or by WBZ for the statistical testing. Statistical graphs and exploratory data analysis will be employed to select the appropriate data grouping and the appropriate statistical tests. Several types of statistical tests (described in the following paragraphs) may be applied to the chemical data collected during the ground water monitoring program at the Delatte site.

3.3.2 Test for Trends

Trend analysis is a statistical tool used to detect and estimate temporal or spatial trends in a data set. Trend analysis is a useful way to evaluate changes within one well or sampling location. Preferably, any data set evaluated for trends over time will have at least eight time-independent observations and a minimum detection rate of 50 percent (EPA 2000). As the number of observations grows over time, so does the certainty of observed trends.

There are several different statistical tests that may be used to evaluate whether a trend exists, with a given probability. The Mann-Kendall test, the Kendall tau test, and Sen's Slope Estimator are appropriate nonparametric tests that are less sensitive to outliers than parametric regression methods. Regression control charts provide graphic depictions of trends and confidence intervals, but unlike the Mann-Kendall and Sen's Slope Estimator, regression control charts are parametric tests that assume a linear relationship between two variables. The characteristics of each data set will be evaluated to determine the appropriate tests to apply.

Trend analysis can be used to evaluate whether the concentrations of a constituent within a single well have increased or decreased over a particular time period. Data will be evaluated in the O&M report to ascertain if contaminant concentrations in each well show statistically significant increases or decreases over time. The critical question for the Delatte site is, "Are concentrations of contaminants in ground water sampled at the site increasing or decreasing over time, as shown by trends in concentrations at each well?"

3.3.3 Statistical Tests Comparing Site Data Against Cleanup Levels

Statistical tests used to compare a data set against a fixed numerical value such as a regulatory standard or threshold value are called "one-sample" tests. Despite the name, these tests actually compare one population (i.e., one data set) against a fixed value, such as an maximum contaminant level (MCL). One-sample tests include both parametric and nonparametric tests. A parametric test, such as the one-sample t-test, assumes that the data are normally (or lognormally) distributed, whereas a nonparametric test, such as the Wilcoxon Rank Sum test, does not assume a particular distribution for the data. Therefore, if the distribution is unknown or if it violates the normality assumption, a nonparametric test may have more power than a corresponding parametric test.

Data from the ground water monitoring program at Delatte will be evaluated using appropriate groupings of the data, as determined by exploratory data analysis. Data may be grouped by well (after 8 quarters of data have been collected), by WBZ, or other type of natural grouping deduced by the exploratory data analysis. Data sets for each group will then be compared to the appropriate fixed value using the most appropriate statistical test.

3.3.4 Statistical Tests Comparing Upgradient and Downgradient Concentrations

"Two-sample" tests are used to compare two data sets (for example, site versus ambient data), rather than two samples (as the name may imply). These tests include both parametric and nonparametric tests. Two-sample parametric tests include the two-sample t-test. Nonparametric tests include the Wilcoxon Rank Sum, the quantile test, and the slippage test. The Wilcoxon Rank Sum test compares the median values of two data sets, whereas the quantile and slippage tests examine the data values in the upper portion of the distribution of the two data sets. Two-sample tests may or may not be useful for evaluating ground water quality at the Delatte site; however, applicability and usefulness of such tests will be examined.

3.3.5 Evaluation of Total and Dissolved Metals

The results of the total and dissolved metals from each well will be compared in order to assess what portion of the metals are suspended and dissolved. These data will be compared to turbidity measurements made during sampling. If the turbidity measured during sampling is less than 10 NTU, the total metals results are considered to be representative of the mobile load in the aquifer and it will not be necessary to collect both filtered and total metal samples. If the turbidity is greater than 10 NTU, a filtered sample will be collected to evaluate the mobile dissolved concentration in the aquifer. Total concentrations minus the dissolved concentrations will be the non-mobile portion (if the total is greater than the dissolved).

3.3.6 Graphing and Contouring Data

The water level results obtained from each monitoring well will be used to develop contour maps and contaminant concentration maps. Contour maps will be developed from each round of sampling and for all three WBZs. The contaminant concentration maps will be developed for each metal of concern within each WBZ. Contaminant data from each well will be plotted graphically to show changes in concentration over time which will aid in the evaluation of trends.

4.0 ROUTINE MAINTENANCE AND INSPECTION

The Contractor shall perform routine maintenance and visual site inspections at the Delatte site to ensure the integrity of the RA. Inspections should be made of the monitoring network. A listing of a schedule of events is presented in Table 4 (Appendix C).

The monitoring wells will be maintained and repaired as necessary. All monitoring wells will be properly labeled and locked. The condition of each monitoring well will be noted during each ground water sampling event and, if necessary, corrective action should be taken. Monitoring wells will be inspected to see if they have suffered any damage since the previous visit due to vehicular traffic, vandalism, or other damage (including screen deterioration). Damage to the concrete pad surrounding each well will be noted, and if severe, the pad may require removal and replacement. Rust or damage to the protective cover may require repainting, or if severe, replacement. Locks that are missing or inoperable will be replaced. If the monitoring well is damaged, it will be evaluated for possible repair. If the damage cannot be repaired, the need for the well will be evaluated based on the previously collected data. If this evaluation shows that the well is still needed, the damaged well will be plugged and abandoned and a replacement well will be installed. If during sampling the well become clogged with sediment, the excess sediment will be removed from the wells by first agitating the water column with a surge block and then removing the sediment with a bailer. If during O&M, the monitoring program changes to remove wells from the sampling schedule, then these wells will be plugged and abandoned.

The deed files for the property will be inspected by the Contractor during the time of sampling to ensure that ICs remain in place.

5.0 REPORTING

Following each sampling/inspection event and receipt of laboratory data, a report describing the sampling activities that occurred, the sample results, the observations made during the site inspection, and the presence of ICs in the deed files will be completed. Recommended corrective measures for issues identified during the inspection will be presented. Statistical analysis of collected data will not be performed until eight sampling events have been conducted.

Specifically, as listed in the LDEQ Bid Specification Document, quarterly reports be prepared in the following manner and shall include:

The quarterly monitoring report shall include the Contractor's name and address, the name of the Project Manager, LDEQ's contract number and project title, a narrative summary of the quarter's operations, and a data summary table providing quarterly and cumulative quantities for the following items:

- (1) A facility map showing all monitoring wells, and depict their status, i.e., assessment, recovery, P/A, etc;
- (2) A table showing well number, well depth, screened interval, zone monitored, well diameter, casing material, and type of dedicated equipment, i.e., pump, bailer, etc. for each well;
- (3) A table showing the sampling and reporting schedule for each well at the facility;
- (4) A table showing which tests are performed for each well and the specific constituents of concern;
- (5) A summary of analytical data for all monitoring wells for the reporting period;
- (6) A discussion of any significant changes from the previous reporting period in the analytical data from all monitoring wells for the reporting period;
- (7) Contaminant concentration isopleths for each monitored zone for the reporting period;
- (8) Water level measurements and potentiometric surface maps for each zone monitored for the reporting period;
- (9) Concentration versus time graphs for all monitor wells installed to monitor the effectiveness of the recovery system;
- (10) Copies of lab data reports, along with validation reports;
- (11) Original field forms / notes; and
- (12) Other pertinent information or discussion.

Note: After the trend analysis, Quarterly Reports shall include a comparison of the quarterly sampling results to the statistical analysis.

6.0 REFERENCES

- U.S. Environmental Protection Agency (EPA). 2000. "Guidance for Data Quality Assessment Practical Methods for Data Analysis". EPA QA/G-9.EPA/600/R-96/084. July.
- EPA. 1996. "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods." SW-846. Third Edition. Update III. December.)
- EPA. 2001. "EPA Contract Laboratory Program Statement of Work for Inorganics Analysis, Multi-Media, Multi-Concentration (ILM05.2)." October.
- Tetra Tech. 2002. "Quality Assurance Project Plan for Remedial Action, Delatte Metals Superfund Site, Ponchatoula, Tangipahoa Parish, Louisiana". Prepared for EPA under Contract No. 68-W6-0037. December 19.
- Tetra Tech. 2000. "Delatte Metals Remedial Investigation Report, Ponchatoula, Louisiana". January.

APPENDIX A

(Formerly - HEALTH AND SAFETY PLAN)

Refer to LDEQ Bid Specifications regarding Health and Safety Requirements.

APPENDIX B

STANDARD OPERATING PROCEDURES

SOP 002 GENERAL EQUIPMENT DECONTAMINATION

**SOP 014 STATIC WATER LEVEL, TOTAL WELL DEPTH AND IMMISCIBLE LAYER
MEASUREMENT**

SOP 015 GROUND WATER SAMPLE COLLECTION USING MICROPURGE TECHNOLOGY

SOP 019 PACKAGING AND SHIPPING SAMPLES

SOP 024 RECORDING OF NOTES IN FIELD LOGBOOK

(41 Pages)

APPENDIX C

TABLES

TABLE 1 MONITORING WELL DATA

TABLE 2 WATER WELL DATA

**TABLE 3 SAMPLE PARAMETER, ANALYSES, VOLUME,
CONTAINER, PRESERVATION, AND HOLDING TIME REQUIREMENTS**

TABLE 4 SCHEDULE OF EVENTS

(Seven Pages)

TABLE 1
MONITORING WELL DATA

Well ID	Northing	Easting	Latitude	Longitude	Well Diameter (inches)	Total Well Depth (ft bgs)	Top of Casing Elevation (NGVD)	Ground Surface Elevation (NGVD)	Screened Interval Elevation (NGVD)	Screened Interval (ft bgs)
First Water-Bearing Zone										
DW-1	701226.57	3571439.32	30E 25' 30"	90E 24' 41"	2	19	13.36	12.03	3.5 to -6.5	8.5 to 18.5
DW-2	700994.96	3571554.52	30E 25' 28"	90E 24' 39"	2	11	14.12	12.65	7.2 to 2.2	5.5 to 10.5
DW-3	701096.8	3571730.91	30E 25' 29"	90E 24' 37"	2	16	11.59	10.09	4.6 to -5.4	5.5 to 15.5
MW-1	701242.6	3571218.61	30E 25' 30"	90E 24' 43"	2	28.5	15.08	13.58	0.6 to -14.4	13.0 to 28.0
MW-2	700954.99	3571119.93	30E 25' 27"	90E 24' 44"	2	10.5	14.23	11.79	6.8 to 1.8	5.0 to 10.0
MW-6	700833.83	3571351.38	30E 25' 26"	90E 24' 42"	2	16.5	16.77	15.17	NA	NA
MW-7	701240.79	3571056.2	30E 25' 30"	90E 24' 45"	2	15	8.21	6.01	NA	NA
(MW-7 Plugged and Abandoned by EPA)										
PW-4	701018.61	3571950.05	30E 25' 28"	90E 24' 35"	2	19.5	12.22	8.96	NA	NA
BA-03	701018.61	3571248.59	30E 25' 28"	90E 24' 43"	2	13.5	14.57	11.8	8.80 to -1.20	3.0 to 13.0
BA-09	701286.58	3571522.59	30E 25' 31"	90E 24' 40"	2	18.0	9.46	8.10	0.60 to -9.40	7.5 to 17.5
BC-31	701305.48	3571090.57	30E 25' 31"	90E 24' 45"	2	16	11.36	8.75	3.25 to -6.75	5.5 to 15.5
(BC-31 Plugged and Abandoned by EPA)										
Second Water-Bearing Zone										
DW-4	700081.39	3571557.42	30E 25' 19"	90E 24' 39"	2	38	14.21	13	-14.5 to -24.5	27.5 to 37.5
MW-A	701114.99	3571481.74	30E 25' 29"	90E 24' 40"	2	27.0	15.12	12.35	-4.2 to -14.2	16.5 to 26.5
MW-3	700801.96	3571573.60	30E 25' 26"	90E 24' 39"	2	27.5	14.80	12.83	-4.2 to 14.2	17.0 to 27.0
MW-4	701248.27	3571817.05	30E 25' 30"	90E 24' 36"	2	24.0	17.38	14.67	1.2 to -8.8	13.5 to 23.5

TABLE 1 (Continued)
MONITORING WELL DATA

Well ID	Northing	Easting	Latitude	Longitude	Well Diameter (inches)	Total Well Depth (ft bgs)	Top of Casing Elevation (NGVD)	Ground Surface Elevation (NGVD)	Screened Interval Elevation (NGVD)	Screened Interval (ft bgs)
Second Water-Bearing Zone (Continued)										
MW-5	701508.89	3571524.34	30E 25' 33"	90E 24' 40"	2	20.0	11.43	8.89	-5.6 to -10.6	14.5 to 19.5
(MW-5 Plugged and Abandoned by EPA)										
BA-01	700965.85	3571653.95	30E 25' 27"	90E 24' 38"	2	26.0	14.57	11.48	-4.02 to -14.02	15.5 to 25.5
BA-05	701084.30	3571574.74	30E 25' 29"	90E 24' 39"	2	18.5	14.20	11.02	3.02 to -6.98	8.0 to 18.0
BA-09A	701290.47	3571515.08	30E 25' 31"	90E 24' 40"	2	42.0	11.10	7.92	-23.58 to -33.58	31.5 to 41.5
BC-01	699516.45	3571517.55	30E 25' 13"	90E 24' 40"	2	26.5	15.99	13.35	-2.65 to -12.65	16.0 to 26.0
(BC-01 Plugged and Abandoned by EPA)										
BC-03	699684.61	3571900.13	30E 25' 15"	90E 24' 36"	2	28.0	16.32	13.78	-3.72 to -13.72	17.5 to 27.5
BC-07	699855.32	3571454.14	30E 25' 16"	90E 24' 41"	2	18.5	11.37	8.19	0.19 to -9.81	8.0 to 18.0
BC-11	699967.64	3571524.00	30E 25' 18"	90E 24' 40"	2	28.5	15.72	12.53	-5.47 to -15.47	18.0 to 28.0
(BC-11 Plugged and Abandoned by EPA)										
BC-17	700232.77	3571685.22	30E 25' 20"	90E 24' 38"	2	28.0	15.18	12.22	-5.28 to -15.28	17.5 to 27.5
BC-19	700257.08	3571479.76	30E 25' 20"	90E 24' 40"	2	22.5	13.85	10.92	-1.08 to -11.08	12.0 to 22.0
BC-21R	700499.25	3571655.52	30E 25' 23"	90E 24' 38"	2	17.5	15.28	12.62	0.62 to -4.38	12.0 to 17.0
BC-25	700599.29	3571504.10	30E 25' 24"	90E 24' 40"	2	32.0	15.73	12.66	-8.84 to -18.84	21.5 to 31.5
BC-27	700721.57	3571738.14	30E 25' 25"	90E 24' 37"	2	28.0	15.91	13.04	-4.46 to -14.46	17.5 to 27.5
(BC-27 Plugged and Abandoned by EPA)										

TABLE 1 (Continued)

MONITORING WELL DATA

Well ID	Northing	Easting	Latitude	Longitude	Well Diameter (inches)	Total Well Depth (ft bgs)	Top of Casing Elevation (NGVD)	Ground Surface Elevation (NGVD)	Screened Interval Elevation (NGVD)	Screened Interval (ft bgs)
Third Water-Bearing Zone										
BA-03A	701004.96	3571249.74	30E 25' 43"	90E 24' 43"	2	100.0	14.76	11.72	-77.78 to -87.78	89.5 to 99.5
BA-05A	701085.48	3571565.29	30E 25' 29"	90E 24' 39"	2	54.0	14.42	11.16	-24.84 to -28.34	36.0 to 39.5
BB-01	699827.30	3571572.41	30E 25' 16"	90E 24' 39"	2	96.0	15.75	12.69	-72.81 to -82.81	85.5 to 95.5
BA-01A	700958.45	3571661.43	30E 25' 27"	90E 24' 38"	2	46.0	15.03	11.61	-23.89 to -33.89	35.5 to 45.5

Notes:

ft bgs Feet below ground surface
ID Identification
NA Not available
NGVD National Geodetic Vertical Datum

TABLE 2
WATER WELL DATA

Well ID	Address	Depth (feet)	Date Installed
WW-04*	39229 Keaghey Rd. Ponchatoula, LA 70454	Unknown	Unknown
WW-09*	39233 Keaghey Rd. Ponchatoula, LA 70454	60	10/94
North Well	19113 Weinberger Road Ponchatoula, LA 70454	Unknown	Unknown
South Well	19113 Weinberger Road Ponchatoula, LA 70454	Unknown	Unknown

Notes:

WW Water well

* Designations for water wells WW-04 and WW-09 were obtained from the Delatte Metals Remedial Investigation Report (Tetra Tech 2000).

TABLE 3

**SAMPLE PARAMETER, ANALYSES, VOLUME, CONTAINER, PRESERVATION, AND
HOLDING TIME REQUIREMENTS**

Parameter	Analytical Method	Volume and Container	Preservation Technique	Holding Time ^a	
				Extraction	Analysis
<u>Total Metals:</u> Arsenic Lead Manganese Nickel Thallium	ILM05.2 ^b	1-1000 mL polyethylene bottle	Store at 4E C, pH<2 HNO ₃	NA	180 Days
<u>Dissolved Metals:</u> Arsenic Lead Manganese Nickel Thallium	ILM05.2 ^b	1-1000 mL polyethylene bottle	Store at 4E C, pH<2 HNO ₃	NA	180 Days

Notes:

EC Degrees centigrade

mL Milliliter

NA Not applicable

< Less than

HNO₃ Nitric acid

^a Holding time is measured from the time of sample collection to the time of sample extraction or analysis

^b EPA. 2001. "EPA Contract Laboratory Program Statement of Work for Inorganics Analysis, Multi-Media, Multi-Concentration (ILM05.2)." October.

^c EPA. 1996. "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods." SW-846. Third Edition. Update III. December.

TABLE 4
SCHEDULE OF EVENTS

Sampling Event	Quarter	Activities	Action
5* (See Note in Row Directly Below)	4 th Q '04	MW sampling On- and off-facility WW sampling Routine inspection <ul style="list-style-type: none"> – ensure MWs are labeled and locked – MW concrete pad – MW protective cover – MW locks (present and functional) – MW damage – site-wide erosion and PRB subsidence 	label and lock as necessary repair as necessary repaint or repair as necessary replace as necessary repair, P&A, replace as necessary import topsoil and replant grass as necessary
NOTE: The on-site tasks for sampling event # 5 will be performed by EPA with shadowing / observation by the incoming LDEQ O&M Contractor. However, the quarterly report for sampling event # 5 will be performed by the incoming LDEQ O&M Contractor.			
6	1 st Q '05	MW sampling On- and off-facility WW sampling Routine inspection <ul style="list-style-type: none"> – ensure MWs are labeled and locked – MW concrete pad – MW protective cover – MW locks (present and functional) – MW damage – site-wide erosion and PRB subsidence 	label and lock as necessary repair as necessary repaint or repair as necessary replace as necessary repair, P&A, replace as necessary import topsoil and replant grass as necessary
7	2 nd Q '05	MW sampling On- and off-facility WW sampling Routine inspection <ul style="list-style-type: none"> – ensure MWs are labeled and locked – MW concrete pad – MW protective cover – MW locks (present and functional) – MW damage – site-wide erosion and PRB subsidence 	label and lock as necessary repair as necessary repaint or repair as necessary replace as necessary repair, P&A, replace as necessary import topsoil and replant grass as necessary

TABLE 4 (Continued)
SCHEDULE OF EVENTS

Sampling Event	Quarter	Activities	Action
8	3 rd Q '05	MW sampling On- and off-facility WW sampling Routine inspection <ul style="list-style-type: none"> – ensure MWs are labeled and locked – MW concrete pad – MW protective cover – MW locks (present and functional) – MW damage – site-wide erosion and PRB subsidence 	label and lock as necessary repair as necessary repaint or repair as necessary replace as necessary repair, P&A, replace as necessary import topsoil and replant grass as necessary.
9 [#]	4 th Q '05	MW sampling On- and off-facility WW sampling Routine inspection <ul style="list-style-type: none"> – ensure MWs are labeled and locked – MW concrete pad – MW protective cover – MW locks (present and functional) – MW damage – site-wide erosion and PRB subsidence 	label and lock as necessary repair as necessary repaint or repair as necessary replace as necessary repair, P&A, replace as necessary import topsoil and replant grass as necessary.

Notes:

MW Monitoring well

P&A Plug and abandon

PRB Permeable reactive barrier

Q Quarter

WW Water well

* O&M activities begin during the 4th quarter of 2004 after four sampling events have taken place. Therefore, O&M begins with the 5th ground water sampling event.

Statistical evaluation of the data can begin.

APPENDIX D

FIGURE

MONITORING AND WATER SUPPLY WELLS TO BE SAMPLED

(One Page)

APPENDIX E
TREND ANALYSIS FOR INTRAWELL COMPARISONS
(Six Pages)

APPENDIX F
LANDOWNER CONTACTS
(Three Pages)

Information in Appendix F is not provided based on the presence of private personal data.

APPENDIX B

STANDARD OPERATING PROCEDURES

SOP 002 GENERAL EQUIPMENT DECONTAMINATION

**SOP 014 STATIC WATER LEVEL, TOTAL WELL DEPTH AND IMMISCIBLE LAYER
MEASUREMENT**

**SOP 015 GROUND WATER SAMPLE COLLECTION USING MICROPURGE
TECHNOLOGY**

SOP 019 PACKAGING AND SHIPPING SAMPLES

SOP 024 RECORDING OF NOTES IN FIELD LOGBOOK

(41 Pages)

SOP APPROVAL FORM

TETRA TECH EM INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

GENERAL EQUIPMENT DECONTAMINATION

SOP NO. 002

REVISION NO. 2

Last Reviewed: December 1999

K. Riesing

Quality Assurance Approved

February 2, 1993

Date

1.0 BACKGROUND

All nondisposable field equipment must be decontaminated before and after each use at each sampling location to obtain representative samples and to reduce the possibility of cross-contamination.

1.1 PURPOSE

This standard operating procedure (SOP) establishes the requirements and procedures for decontaminating equipment in the field.

1.2 SCOPE

This SOP applies to decontaminating general nondisposable field equipment. To prevent contamination of samples, all sampling equipment must be thoroughly cleaned prior to each use.

1.3 DEFINITIONS

Alconox: Nonphosphate soap

1.4 REFERENCES

U.S. Environmental Protection Agency (EPA). 1992. "RCRA Ground-Water Monitoring: Draft Technical Guidance. Office of Solid Waste. Washington, DC. EPA/530-R-93-001. November.

EPA. 1994. "Sampling Equipment Decontamination." Environmental Response Team SOP #2006 (Rev. #0.0, 08/11/94). On-Line Address: http://204.46.140.12/media_resrcs/media_resrcs.asp?Child1=

1.5 REQUIREMENTS AND RESOURCES

The equipment required to conduct decontamination is as follows:

- Scrub brushes
- Large wash tubs or buckets
- Squirt bottles

- Alconox
- Tap water
- Distilled water
- Plastic sheeting
- Aluminum foil
- Methanol or hexane
- Dilute (0.1 N) nitric acid

2.0 PROCEDURE

The procedures below discuss decontamination of personal protective equipment (PPE), drilling and monitoring well installation equipment, borehole soil sampling equipment, water level measurement equipment, and general sampling equipment.

2.1 PERSONAL PROTECTIVE EQUIPMENT DECONTAMINATION

Personnel working in the field are required to follow specific procedures for decontamination prior to leaving the work area so that contamination is not spread off-site or to clean areas. All used disposable protective clothing, such as Tyvek coveralls, gloves, and booties, will be containerized for later disposal. Decontamination water will be containerized in 55-gallon drums.

Personnel decontamination procedures will be as follows:

1. Wash neoprene boots (or neoprene boots with disposable booties) with Liquinox or Alconox solution and rinse with clean water. Remove booties and retain boots for subsequent reuse.
2. Wash outer gloves in Liquinox or Alconox solution and rinse in clean water. Remove outer gloves and place into plastic bag for disposal.
3. Remove Tyvek or coveralls. Containerize Tyvek for disposal and place coveralls in plastic bag for reuse.
4. Remove air purifying respirator (APR), if used, and place the spent filters into a plastic bag for disposal. Filters should be changed daily or sooner depending on use and application. Place respirator into a separate plastic bag after cleaning and disinfecting.
5. Remove disposable gloves and place them in plastic bag for disposal.

6. Thoroughly wash hands and face in clean water and soap.

2.2 DRILLING AND MONITORING WELL INSTALLATION EQUIPMENT DECONTAMINATION

All drilling equipment should be decontaminated at a designated location on-site before drilling operations begin, between borings, and at completion of the project.

Monitoring well casing, screens, and fittings are assumed to be delivered to the site in a clean condition. However, they should be steam cleaned on-site prior to placement downhole. The drilling subcontractor will typically furnish the steam cleaner and water.

After cleaning the drilling equipment, field personnel should place the drilling equipment, well casing and screens, and any other equipment that will go into the hole on clean polyethylene sheeting.

The drilling auger, bits, drill pipe, temporary casing, surface casing, and other equipment should be decontaminated by the drilling subcontractor by hosing down with a steam cleaner until thoroughly clean. Drill bits and tools that still exhibit particles of soil after the first washing should be scrubbed with a wire brush and then rinsed again with a high-pressure steam rinse.

All wastewater from decontamination procedures should be containerized.

2.3 BOREHOLE SOIL SAMPLING EQUIPMENT DECONTAMINATION

The soil sampling equipment should be decontaminated after each sample as follows:

1. Prior to sampling, scrub the split-barrel sampler and sampling tools in a bucket using a stiff, long bristle brush and Liquinox or Alconox solution.
2. Steam clean the sampling equipment over the rinsate tub and allow to air dry.
3. Place cleaned equipment in a clean area on plastic sheeting and wrap with aluminum foil.
4. Containerize all water and rinsate.

5. Decontaminate all pipe placed down the hole as described for drilling equipment.

2.4 WATER LEVEL MEASUREMENT EQUIPMENT DECONTAMINATION

Field personnel should decontaminate the well sounder and interface probe before inserting and after removing them from each well. The following decontamination procedures should be used:

1. Wipe the sounding cable with a disposable soap-impregnated cloth or paper towel.
2. Rinse with deionized organic-free water.

2.5 GENERAL SAMPLING EQUIPMENT DECONTAMINATION

All nondisposable sampling equipment should be decontaminated using the following procedures:

1. Select an area removed from sampling locations that is both downwind and downgradient. Decontamination must not cause cross-contamination between sampling points.
2. Maintain the same level of protection as was used for sampling.
3. To decontaminate a piece of equipment, use an Alconox wash; a tap water wash; a solvent (methanol or hexane) rinse, if applicable or dilute (0.1 N) nitric acid rinse, if applicable; a distilled water rinse; and air drying. Use a solvent (methanol or hexane) rinse for grossly contaminated equipment (for example, equipment that is not readily cleaned by the Alconox wash). The dilute nitric acid rinse may be used if metals are the analyte of concern.
4. Place cleaned equipment in a clean area on plastic sheeting and wrap with aluminum foil.
5. Containerize all water and rinsate.

SOP APPROVAL FORM

TETRA TECH EM INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

**STATIC WATER LEVEL, TOTAL WELL DEPTH,
AND IMMISCIBLE LAYER MEASUREMENT**

SOP NO. 014

REVISION NO. 0

Last Reviewed: December 1999

K. Riesing

Quality Assurance Approved

July 20, 1994

Date

1.0 BACKGROUND

Measurement of static water level, total well depth, and any immiscible layers is necessary before a well can be sampled and groundwater flow direction can be determined. If an immiscible layer is present, its depth and thickness must be determined. In addition, the static water level and total depth of a monitoring well are needed to determine a purging volume.

1.1 PURPOSE

The purpose of this standard operating procedure (SOP) is to provide guidelines for field personnel measuring static water levels and total water depths of monitoring wells or piezometers. This SOP also provides guidelines for measuring immiscible layers in such wells.

1.2 SCOPE

This SOP describes the methodologies for measuring static water level, total well depth, and immiscible layer depth and thickness.

1.3 DEFINITIONS

To clarify the methodologies presented in this SOP, the following definitions are presented:

Electrical Water Level Indicator: An electrical probe used to determine the depth to fluid. The probe has a light or sound alarm connected to an open circuit. The circuit is closed and the alarm is activated when the probe contacts a conducting fluid such as water.

Immiscible Layer: A liquid phase that cannot be uniformly mixed or blended with water. Heavy immiscible phases sink in water; light immiscible phases float on water.

Interface Probe: An electrical probe used to determine the thicknesses of light or dense immiscible layers in the water column of a monitoring well.

Ionization Detector: A photoionization detector (PID) or a flame ionization detector (FID) is used to measure the level of volatile organic compounds in the gaseous phase. These units are generally not compound-specific and thus measure only total volatile organic compounds. The PID generally cannot detect as complete a range of compounds as the FID. This difference is the result of the relative ionization energies of the two detectors. Most PIDs cannot detect methane, but FIDs can. The HNu and Microtip are examples of PIDs; the Foxboro organic vapor analyzer (OVA) is an example of an FID.

Static Water Level: The level of water in a monitoring well or piezometer. This level can be measured as the depth to water or as the elevation of water relative to a reference mark or datum.

Total Well Depth: The distance from the ground surface to the bottom of a monitoring well or piezometer

1.4 REFERENCES

SOP No. 002, General Equipment Decontamination

U.S. Environmental Protection Agency. 1994. "Water Level Measurement." Environmental Response Team SOP #2043 (Rev. #0.0, 10/03/94). On-Line Address:
http://204.46.140.12/media_resrcs/media_resrcs.asp?Child1=

1.5 REQUIREMENTS AND RESOURCES

The equipment required for measuring static water levels, total well depths, and immiscible layers is as follows:

- Electrical water level indicator
- Interface probe
- PID or FID

2.0 PROCEDURES

This section provides general guidance followed by specific procedures for static water level, total well depth, and immiscible layer measurement.

Techniques for measuring depth to water and depth to the bottom of a monitoring well should be identified in the planning stage of field work. Also at this stage, measuring devices should be chosen, and an individual should be assigned to take and record measurements.

All measurement instruments should be decontaminated before and after use and between measurement locations. Refer to SOP No. 002, General Equipment Decontamination.

Before initiating any measuring activities, the ambient air at a monitoring well head should be monitored for possible emissions of volatile organic compounds. To accomplish this monitoring, a PID or an FID should be used. The health and safety plan for on-site activities should provide action levels and the rationale for selection of either detector.

Appropriate respiratory protection equipment should be worn by the sampling team. Wells should be approached from the upwind side. When opening the monitoring well, the sampling team should systematically survey the inside of the well casing, the area from the casing to the ground, the area from above the well casing to the breathing zone, and the area around the well. Readings for comparison to action levels should be taken not within the well casing but in the breathing zone. If PID or FID readings of volatile organic compounds are above action levels, the sampling team should retreat to a safe area and put on appropriate safety gear. The site-specific health and safety plan should be consulted for action levels.

2.1 STATIC WATER LEVEL MEASUREMENT

The procedure described below should be followed to measure the static water level in a monitoring well or piezometer.

An electric water level indicator is typically used for static water level measurement. The electrical probe of the indicator should be lowered into the monitoring well until the light or sound alarm is activated, indicating that the probe has touched the water surface. The static water level should then be read directly from the indicator to the 0.01-foot fraction. If the monitoring well top is not flush with the ground surface, the distance between the static water level and the top of the riser pipe should be measured; the height of the riser pipe above ground surface should then be subtracted from the first measurement to determine the depth to static water below ground surface. If surveyed elevations are available, they should be used to establish the water level elevation. To ensure measurement accuracy, the probe should be left hanging above the water surface in the monitoring well; a series of three readings should be taken, and the values should be averaged. The measurement date and time, individual readings, and the average of the readings should be recorded in a field logbook.

2.2 TOTAL WELL DEPTH MEASUREMENT

The procedure described below should be followed to measure total well depth in a monitoring well or piezometer.

Total well depth measurement can be performed also using an electric water level indicator. The electrical probe of the indicator should be lowered into the monitoring well until resistance is met, indicating that the probe has reached the bottom of the well. The total well depth should then be read directly from the indicator to the 0.01-foot fraction. If the monitoring well top is not flush with the ground surface, the distance between the bottom of the well and the top of the riser pipe should be measured; the height of the riser pipe above ground surface should then be subtracted from the first measurement to determine the depth from ground surface to the bottom of the well. To ensure measurement accuracy, the probe should be left hanging above the water surface in the monitoring well; a series of three readings should be taken, and the values should be averaged. The measurement date and time, individual readings, and the average of the readings should be recorded in a field logbook.

2.3 IMMISCIBLE LAYER DETECTION AND MEASUREMENT

The procedure described below should be followed to detect and measure an immiscible layer in a monitoring well.

A light immiscible layer in a monitoring well can be detected by slowly lowering an interface probe to the surface of the water in the well. When the audible alarm sounds, the depth of the probe should be recorded. If the alarm is continuous, a light immiscible layer has been detected. To measure the thickness of this layer, the probe should then be lowered until the alarm changes to an oscillating signal. The oscillating alarm indicates that the probe has reached a water layer. The probe depth at the time the alarm begins oscillating should be recorded as the depth to water. The thickness of the light immiscible layer should then be determined by subtracting the depth at which a continuous alarm occurred from the depth at which the alarm began to oscillate. To ensure measurement accuracy, the interface probe should be left hanging above the water surface in the monitoring well; a series of three readings should be taken, and the depths and thicknesses measured should be averaged. The measurement date and time, individual readings for depth and thickness, and average values for depth and thickness should be recorded in a field logbook.

To determine whether a dense immiscible layer is present, the interface probe should be lowered further into the monitoring well. If the alarm changes from an oscillating to a continuous signal, a heavier immiscible layer has been detected, and the probe depth should be recorded at that point. Total well depth obtained in Section 2.2 should be used for calculating the thickness of the dense layer. The dense layer should be calculated by subtracting the depth at which the alarm became continuous from the total well depth. This procedure provides an estimate of the thickness of the dense layer in the monitoring well. To ensure measurement accuracy, the interface probe should be left hanging above the water surface in the monitoring well; a series of three readings should be taken, and the depths and thicknesses measured should be averaged. The measurement date and time, individual readings for depth and thickness, and average values for depth and thickness should be recorded in a field logbook.

SOP APPROVAL FORM

TETRA TECH EM INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

**GROUNDWATER SAMPLE COLLECTION
USING MICROPURGE TECHNOLOGY**

SOP NO. 015

REVISION NO. 0

Last Reviewed: January 2000

K. Riesing

Quality Assurance Approved

April 7, 1998

Date

1.0 BACKGROUND

Groundwater sample collection is an integral part of site characterization at many contaminant release investigation sites. Often, a requirement of groundwater contaminant investigation is to evaluate contaminant concentrations in the aquifer. Since data quality objectives of most investigations require a laboratory setting for chemical analysis, samples must be collected from the aquifer and submitted to a laboratory for analysis. Therefore, sample collection and handling must be conducted in a manner that minimizes alteration of chemical characteristics of the groundwater.

In the past, most sample collection techniques followed federal and state guidance. Acceptable protocol included removal of water in the casing of a monitoring well (purging), followed by sample collection. The water in the casing was removed so groundwater from the formation could flow into the casing and be available for sample collection. Sample collection was commonly completed with a bailer, bladder pump, controlled flow impeller pump, or peristaltic pump. Samples were preserved during collection. Often, samples to be analyzed for metals contamination were filtered through a 0.45-micron filter prior to preservation and placement into the sample container.

Research conducted by several investigators has demonstrated that a significant component of contaminant transport occurs while the contaminant is sorbed onto colloid particles. Colloid mobility in an aquifer is a complex, aquifer-specific transport issue, and its description is beyond the scope of this Standard Operating Procedure (SOP). However, concentrations of suspended colloids have been measured during steady state conditions and during purging activities. Investigation results indicate standard purging procedures can cause a significant increase in colloid concentrations, which in turn may bias analytical results.

Micropurge sample collection provides a method of minimizing increased colloid mobilization by removing water from the well at the screened interval at a rate that preserves or minimally disrupts steady-state flow conditions in the aquifer. During micropurge sampling, groundwater is discharged from the aquifer at a rate that the aquifer will yield without creating a cone of depression around the sampled well. Research indicates that colloid mobilization will not increase above steady-state conditions during low-flow discharge. Therefore, the collected sample is more likely to represent steady-state groundwater chemistry.

1.1 PURPOSE

The purpose of this SOP is to describe the procedures to be used to collect a groundwater sample from a well using the micropurge technology. The following sections describe the equipment to be used and the methods to be followed to promote uniform sample collection techniques by field personnel that are experienced in sample collection and handling for environmental investigations.

1.2 SCOPE

This SOP applies to groundwater sampling using the micropurge technology. It is intended to be used as an alternate SOP to the general "Groundwater Sampling" SOP (SOP No. 10) that provides guidance for the general aspects of groundwater sampling.

1.3 DEFINITIONS

Colloid: Suspended particles that range in diameter from 5 nanometers to 0.2 micrometers.

Dissolved oxygen: The ratio of the concentration or mass of oxygen in water relative to the partial pressure of gaseous oxygen above the liquid which is a function of temperature, pressure, and concentration of other solutes.

Flow-through cell: A device connected to the discharge line of a groundwater purge pump that allows regular or continuous measurement of selected parameters of the water and minimizes contact between the water and air.

pH: The negative base-10 log of the hydrogen-ion activity in moles per liter.

Reduction and oxidation potential: A numerical index of the intensity of oxidizing or reducing conditions within a system, with the hydrogen-electrode potential serving as a reference point of zero volts.

Specific conductance: The reciprocal of the resistance in ohms measured between opposite faces of a centimeter cube of aqueous solution at a specified temperature.

Turbidity: A measurement of the suspended particles in a liquid that have the ability to reflect or refract part of the visible portion of the light spectrum.

1.4 REFERENCES

Puls, R. W. and M. J. Barcelona. 1996. Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures. U.S. Environmental Protection Agency. Office of Research and Development. EPA/540/S-95/504. April.

1.5 REQUIREMENTS AND RESOURCES

The following equipment is required to complete micropurge sample collection :

- Water level indicator
- Adjustable flow rate pump (bladder, piston, peristaltic, or impeller)
- Discharge flow controller
- Flow-through cell
- pH probe
- Dissolved oxygen (DO) probe
- Turbidity meter
- Oxidation and reduction (Redox or Eh) probe
- Specific conductance (SC) probe (optional)
- Temperature probe (optional)
- Meter to display data for the probes
- Calibration solutions for pH, SC, turbidity, and DO probes, as necessary
- Container of known volume for flow measurement or calibrated flow meter
- Data recording and management system

2.0 PROCEDURE

The following procedures and criteria were modified from the U. S. Environmental Protection Agency guidance titled “Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures” (Puls and Barcelona 1996). This reference may be consulted for a more detailed description of micropurge sampling theory.

Micropurging is most commonly accomplished with low-discharge rate pumps, such as bladder pumps, piston pumps, controlled velocity impeller pumps, or peristaltic pumps. Bailers and high capacity submersible pumps are not considered acceptable micropurge sample collection devices. The purged water is monitored (in a flow-through cell or other constituent monitoring device) for chemical and optical parameters that indicate steady state flow conditions between the sample extraction point and the aquifer. Samples are collected when steady state conditions are indicated.

Groundwater discharge equipment may be permanently installed in the monitoring well as a dedicated system, or it can be installed in each well as needed. Most investigators agree that dedicated systems will provide the best opportunity for collecting samples most representative of steady state aquifer conditions, but the scope of a particular investigation and available investigation funds will dictate equipment selection.

2.1 EQUIPMENT CALIBRATION

Prior to sample collection, the monitoring equipment used to measure pH, Eh, DO, turbidity, and SC should be calibrated or checked according to manufacturer’s directions. Typically, calibration activities are completed at the field office at the beginning of sampling activities each day. The pH meter calibration should bracket the pH range of the wells to be sampled (acidic to neutral pH range [4.00 to 7.00] or neutral to basic pH range [7.00 to 10.00]). The DO meter should be calibrated to one point (air-saturated water) or two points (air-saturated water and water devoid of all oxygen). The SC meter cannot be calibrated in the field. It is checked against a known standard (typical standards are 1, 10, and 50 millimhos per centimeter at 25 °C). The offset of the measured value of the calibration standard can be used as a correction value. Similarly, the Eh probe cannot be calibrated in the field, but is checked against a known standard, such as Zobell solution. The instrument should display a millivolt (mv) value that falls within the

range set by the manufacturer. Because Eh is temperature dependent, the measured value should be corrected for site-specific variance from standard temperature (25 °C). The Eh probe should be replaced if the reading is not within the manufacturer's specified range. All calibration data should be recorded on the Micropurging Groundwater Sampling Data Sheet attached to this SOP or in a logbook.

2.2 WELL PURGING

The well to be sampled should be opened and groundwater in the well allowed to equilibrate to atmospheric pressure. Equilibration should be determined by measuring depth to water below the marked reference on the wellhead (typically the top of the well casing) over two or more 5-minute intervals. Equilibrium conditions exist when the measured depth to water varies by less than 0.01 foot over two consecutive readings. Total depth of well measurement should be made following sample collection, unless the datum is required to place nondedicated sample collection equipment. Depth to water and total well depth measurements should be made in accordance with procedures outlined in SOP No. 014 (Static Water Level, Total Well Depth, and Immiscible Layer Measurement).

If the well does not have a dedicated sample collection device, a new or previously decontaminated portable sample collection device should be placed within the well. The intake of the device should be positioned at the midpoint of the well screen interval. The device should be installed slowly to minimize turbulence within the water in the casing and mixing of stagnant water above the screened interval with water in the screened interval. Following installation, the flow controller should be connected to the sample collection device and the flow-through cell connected to the outlet of the sample collection device. The calibrated groundwater chemistry monitoring probes should be installed in the flow-through cell. If a flow meter is used, it should be installed ahead of the flow-through cell.

If the well has a dedicated sample collection device, the controller for the sample collection device should be connected to the sample collection device. The flow meter and flow-through cell should be connected in line to the discharge tube, and the probes installed in the flow-through cell.

The controller should be activated and groundwater extracted (purged) from the well. The purge rate should be monitored, and should not exceed the capacity of the well. The well capacity is defined as the

maximum discharge rate that can be obtained with less than 0.1 meter (0.3 foot) drawdown. Typically, the discharge rate will be less than 0.5 liters per minute (L/min) (0.13 gallons per minute). The maximum purge rate should not exceed 1 L/min (0.25 gallons per minute), and should be adjusted to achieve minimal drawdown.

Water levels, effluent chemistry, and effluent flow rate should be continuously monitored while purging the well. Purging should continue until the measured chemical and optical parameters are stable. Stable parameters are defined as monitored chemistry values that do not fluctuate by more than the following ranges over three successive readings at 3-minute intervals: ± 0.1 pH unit; ± 3 percent for SC; ± 10 mv for Eh; and ± 10 percent for turbidity and DO. Purging will continue until these stabilization criteria have been met or three well casing volumes have been purged. If three casing volumes of water have been purged and the stabilization criteria have not been met, a comment should be made on the data sheet that sample collection began after three well casing volumes were purged. The final pH, SC, Eh, turbidity, and DO values will be recorded. All data should be recorded on the Micropurging Groundwater Sampling Data Sheet attached to this SOP or in a logbook.

2.3 SAMPLE COLLECTION

Following purging, the flow through cell shall be disconnected, and groundwater samples collected directly from the discharge line. Discharge rates should be adjusted so that groundwater is dispensed into the sample container with minimal aeration of the sample. Samples collected for volatile organic compound analysis should be dispensed into the sample container at a flow rate equal to or less than 100 milliliters per minute. Samples should be preserved and handled as described in the investigation field sampling plan or quality assurance project plan.



MICROPURGING GROUNDWATER SAMPLING DATA SHEET

Page ____ of ____

Date _____

Well Name _____	Screen Interval _____	Station Elevation _____ GND _____ TOC _____
Project _____	Static Water Level (from TOC) _____	Immiscible Phases Present <input type="checkbox"/> Yes <input type="checkbox"/> No
Project No. _____	Well Stick Up _____	Type _____
Well Location _____	Static Elevation _____	Measured with _____
Sample Date _____	Well Depth _____ MEAS _____ RPTD _____	PID Readings (background) _____
Sampling Personnel _____	Feet of Water _____	PID Reading (TOC) _____
_____	Gallons/Foot _____	Wells Installed by _____
Sample ID _____	Casing Volume _____	Installation Date _____
Duplicate ID _____		Development Date(s) _____

FIELD CHEMISTRY CALIBRATIONS

Date/Time _____ Spec. Conductance: Standard _____ $\mu\text{mhos/cm}$ at 25°C Reading _____ $\mu\text{mhos/cm}$ at _____°C
 pH: pH 4.00 - _____ at _____°C pH 7.00 - _____ at _____°C pH 10.00 - _____ at _____°C Slope _____
 Dissolved Oxygen: D.O. Meter _____ mg/L at _____°C PID: Calibration Gas _____ PPM _____ Span _____ Reading _____

PURGING													
Time	Discharge Rate (mL/min)	Dissolved Oxygen (mg/L)	pH	Eh/ORP (mV)	Temp. (°C)	Specific Conduct. ($\mu\text{mhos/cm}$ at °C)	Turbidity (NTU)	Cumulative Volume of Water Removed (Purged)		PID/OVA Reading		Depth to Water (ft)	Comments
								Gallons	Casing Vol.	Location	Value		

SAMPLE PARAMETERS

--	--	--	--	--	--	--	--	--	--	--	--	--	--

Condition of well: _____

Remarks: _____

FIELD EQUIPMENT

pH Meter _____	Serial Number _____	Field Chemistry Calibrations
Spec. Cond. Meter _____	Serial Number _____	Fractions _____
Pump _____	Serial Number _____	
Water Level Meter _____	Serial Number _____	Number of Bottles _____
D.O. Meter _____	Serial Number _____	Sample Depth _____
Filter Apparatus _____	Filters _____	Field Notebook _____
Temperature Measure _____		Sample Method _____
Interface Probe _____	Serial Number _____	
PID/OVA _____	Serial Number _____	Discharge Water Containerized <input type="checkbox"/> Yes <input type="checkbox"/> No

SOP APPROVAL FORM

TETRA TECH EM INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

PACKAGING AND SHIPPING SAMPLES

SOP NO. 019

REVISION NO. 5

Last Reviewed: January 2000



Quality Assurance Approved

January 28, 2000

Date

1.0 BACKGROUND

In any sampling program, the integrity of a sample must be ensured from its point of collection to its final disposition. Procedures for classifying, packaging, and shipping samples are described below. Steps in the procedures should be followed to ensure sample integrity and to protect the welfare of persons involved in shipping and receiving samples. When hazardous substances and dangerous goods are sent by common carrier, their packaging, labeling, and shipping are regulated by the U.S. Department of Transportation (DOT) Hazardous Materials Regulations (HMR, *Code of Federal Regulations*, Title 49 [49 CFR] Parts 106 through 180) and the International Air Transportation Association (IATA) Dangerous Goods Regulations (DGR).

1.1 PURPOSE

This standard operating procedure (SOP) establishes the requirements and procedures for packaging and shipping samples. It has been prepared in accordance with the U.S. Environmental Protection Agency (EPA) "Sampler's Guide to the Contract Laboratory Program (CLP)," the DGR, and the HMR. Sample packaging and shipping procedures described in this SOP should be followed for all sample packaging and shipping. Deviations from the procedures in this SOP must be documented in a field logbook. This SOP assumes that samples are already collected in the appropriate sample jars and that the sample jars are labeled and tagged appropriately.

1.2 SCOPE

This SOP applies to sample classification, packaging, and shipping.

1.3 DEFINITIONS

Custody seal: A custody seal is a tape-like seal. Placement of the custody seal is part of the chain-of-custody process and is used to prevent tampering with samples after they have been packaged for shipping.

Dangerous goods: Dangerous goods are articles or substances that can pose a significant risk to health, safety, or property when transported by air; they are classified as defined in Section 3 of the DGR (IATA 1999).

Environmental samples: Environmental samples include drinking water, most groundwater and ambient surface water, soil, sediment, treated municipal and industrial wastewater effluent, and biological specimens. Environmental samples typically contain low concentrations of contaminants and when handled require only limited precautionary procedures.

Hazardous Materials Regulations: The HMR are DOT regulations for the shipment of hazardous materials by air, water, and land; they are located in 49 CFR 106 through 180.

Hazardous samples: Hazardous samples include dangerous goods and hazardous substances. Hazardous samples shipped by air should be packaged and labeled in accordance with procedures specified by the DGR; ground shipments should be packaged and labeled in accordance with the HMR.

Hazardous substance: A hazardous substance is any material, including its mixtures and solutions, that is listed in Appendix A of 49 CFR 172.101 and its quantity, in one package, equals or exceeds the reportable quantity (RQ) listed in the appendix.

IATA Dangerous Goods Regulations: The DGR are regulations that govern the international transport of dangerous goods by air. The DGR are based on the International Civil Aviation Organization (ICAO) Technical Instructions. The DGR contain all of the requirements of the ICAO Technical Instructions and are more restrictive in some instances.

Nonhazardous samples: Nonhazardous samples are those samples that do not meet the definition of a hazardous sample and **do not** need to be packaged and shipped in accordance with the DGR or HMR.

Overpack: An enclosure used by a single shipper to contain one or more packages and to form one handling unit (IATA 1999). For example, a cardboard box may be used to contain three fiberboard boxes to make handling easier and to save on shipping costs.

1.4 REFERENCES

U.S. Department of Transportation, Transport Canada, and the Secretariat of Communications and Transportation of Mexico (DOT and others). 1996. "1996 North American Emergency Response Guidebook."

International Air Transport Association (IATA). 1997. "Guidelines for Instructors of Dangerous Courses."

IATA. 1999. "Dangerous Goods Regulations." 40th Edition.

U.S. Environmental Protection Agency. 1996. "Sampler's Guide to the Contract Laboratory Program." Office of Solid Waste and Emergency Response. Washington, DC. EPA/540/R-96/032. On-Line Address: <http://www.epa.gov/oerrpage/superfund/programs/clp/guidance.htm#sample>

1.5 REQUIREMENTS AND RESOURCES

The procedures for packaging and shipping **nonhazardous** samples require the following:

- Coolers
- Ice
- Vermiculite, bubble wrap, or similar cushioning material
- Chain-of-custody forms and seals
- Airbills
- Resealable plastic bags for sample jars and ice
- Tape (strapping and clear)

The procedures for packaging and shipping **hazardous** samples require the following:

- Ice
- Vermiculite or other non-combustible, absorbent packing material
- Chain-of-custody forms and seals
- Appropriate dangerous goods airbills and emergency response information to attach to the airbill

- Resealable plastic bags for sample jars and ice
- Tape (strapping and clear)
- Appropriate shipping containers as specified in the DGR
- Labels that apply to the shipment such as hazard labels, address labels, “Cargo Aircraft Only” labels, and package orientation labels (up arrows)

2.0 PROCEDURES

The following procedures apply to packaging and shipping nonhazardous and hazardous samples.

2.1 SAMPLE CLASSIFICATION

Prior to sample shipment, it must be determined whether the sample is subject to the DGR. Samples subject to these regulations shall be referred to as hazardous samples. If the hazardous sample is to be shipped by air, then the DGR should be followed. Any airline, including FedEx, belonging to IATA must follow the DGR. As a result, FedEx **may not** accept a shipment that is packaged and labeled in accordance with the HMR (although in most cases, the packaging and labeling would be the same for either set of regulations). The HMR states that a hazardous material may be transported by aircraft in accordance with the ICAO Technical Instruction (49 CFR 171.11) upon which the DGR is based. Therefore, the use of the DGR for samples to be shipped by air complies with the HMR, but not vice versa.

Most environmental samples are not hazardous samples and do not need to be packaged in accordance with any regulations. Hazardous samples are those samples that can be classified as specified in Section 3 of the DGR, can be found in the List of Dangerous Goods in the DGR in bold type, are considered a hazardous substance (see definition), or are mentioned in “Section 2 - Limitations” of the DGR for countries of transport or airlines (such as FedEx). The hazard classifications specified in the DGR (and the HMR) are as follows:

Class 1 - Explosives

Division 1.1 - Articles and substances having a mass explosion hazard

- Division 1.2 - Articles and substances having a projection hazard but not a mass explosion hazard
- Division 1.3 - Articles and substances having a fire hazard, a minor blast hazard and/or a minor projection hazard but not a mass explosion hazard
- Division 1.4 - Articles and substances presenting no significant hazard
- Division 1.5 - Very sensitive substances mass explosion hazard
- Division 1.6 - Extremely insensitive articles which do not have a mass explosion hazard

Class 2 - Gases

- Division 2.1 - Flammable gas
- Division 2.2 - Non-flammable, non-toxic gas
- Division 2.3 - Toxic gas

Class 3 - Flammable Liquids

Class 4 - Flammable Solids; Substances Liable to Spontaneous Combustion; Substances, which, in Contact with Water, Emit Flammable Gases

- Division 4.1 - Flammable solids.
- Division 4.2 - Substances liable to spontaneous combustion.
- Division 4.3 - Substances, which, in contact with water, emit flammable gases.

Class 5 - Oxidizing Substances and Organic Peroxide

- Division 5.1 - Oxidizers.
- Division 5.2 - Organic peroxides.

Class 6 - Toxic and Infectious Substances

- Division 6.1 - Toxic substances.
- Division 6.2 - Infectious substances.

Class 7 - Radioactive Material

Class 8 - Corrosives

Class 9 - Miscellaneous Dangerous Goods

The criteria for each of the first eight classes are very specific and are outlined in Section 3 of the DGR and 49 CFR 173 of the HMR. Some classes and divisions are further divided into packing groups based on their level of danger. Packing group I indicates a great danger, packing group II indicates a medium danger, and packing group III indicates a minor danger. Class 2, gases, includes any compressed gas being

shipped and any noncompressed gas that is either flammable or toxic. A compressed gas is defined as having a pressure over 40 pounds per square inch (psi) absolute (25 psi gauge). Most air samples and empty cylinders that did not contain a flammable or toxic gas are exempt from the regulations. An empty hydrogen cylinder, as in a flame ionization detector (FID), is considered a dangerous good unless it is properly purged with nitrogen in accordance with the HMR. A landfill gas sample is usually considered a flammable gas because it may contain a high percentage of methane. Class 3, flammable liquids, are based on the boiling point and flash point of a substance. Most class 3 samples include solvents, oil, gas, or paint-related material collected from drums, tanks, or pits. Division 6.1, toxic substances, is based on oral toxicity (LD₅₀ [lethal dose that kills 50 percent of the test animals]), dermal toxicity (LD₅₀ values), and inhalation toxicity (LC₅₀ [lethal concentration that kills 50 percent of the test animals] values).

Division 6.1 substances include pesticides and cyanide. Class 7, radioactive material, is defined as any article or substance with a specific activity greater than 70 kiloBecquerels (kBq/kg) (0.002 [microCuries per gram [μCi/g]). If the specific activity exceeds this level, the sample should be shipped in accordance with Section 10 of the DGR. Class 8, corrosives, are based on the rate at which a substance destroys skin tissue or corrodes steel; they are not based on pH. Class 8 materials include the concentrated acids used to preserve water samples. Preserved water samples are not considered class 8 substances and should be packaged as nonhazardous samples. Class 9, miscellaneous dangerous goods, are substances that present a danger but are not covered by any other hazard class. Examples of class 9 substances include asbestos, polychlorinated biphenyls (PCB), and dry ice.

Unlike the DGR, the HMR includes combustible liquids in hazard class 3. The definition of a combustible liquid is specified in 49 CFR 173.120 of the HMR. The HMR has an additional class, ORM-D, that is not specified in the DGR. “ORM-D material” refers to a material such as a consumer commodity, that although otherwise subject to the HMR, presents a limited hazard during transport due to its form, quantity, and packaging. It must be a material for which exceptions are provided in the table of 49 CFR 172.101. The DGR lists consumer commodities as a class 9 material.

In most instances, the hazard of a material sampled is unknown because no laboratory testing has been conducted. A determination as to the suspected hazard of the sample must be made using knowledge of the site, field observations, field tests, and other available information.

According to 40 CFR 261.4(d) and (e), samples transported to a laboratory for testing or treatability studies, including samples of hazardous wastes, are **not** hazardous wastes. FedEx will not accept a shipment of hazardous waste.

2.2 PACKAGING NONHAZARDOUS SAMPLES

Nonhazardous samples, after being appropriately containerized, labeled, and tagged, should be packaged in the following manner. Note that these are general instructions; samplers should be aware of any client-specific requirements concerning the placement of custody seals or other packaging provisions.

1. Place the sample in a resealable plastic bag.
2. Place the bagged sample in a cooler and pack it to prevent breakage.
3. Prevent breakage of bottles during shipment by either wrapping the sample container in bubble wrap, or lining the cooler with a noncombustible material such as vermiculite. Vermiculite is especially recommended because it will absorb any free liquids inside the cooler. It is recommended that the cooler be lined with a large plastic garbage bag before samples, ice, and absorbent packing material are placed in the cooler.
4. Add a sufficient quantity of ice to the cooler to cool samples to 4 °C. Ice should be double bagged in resealable plastic bags to prevent the melted ice from leaking out. As an option, a temperature blank (a sample bottle filled with distilled water) can be included with the cooler.
5. Seal the completed chain-of-custody forms in a plastic bag and tape the plastic bag to the inside of the cooler lid.
6. Tape any instructions for returning the cooler to the inside of the lid.
7. Close the lid of the cooler and tape it shut by wrapping strapping tape around both ends and hinges of the cooler at least once. Tape shut any drain plugs on the cooler.
8. Place two signed custody seals on the cooler, ensuring that each one covers the cooler lid and side of the cooler. Place clear plastic tape over the custody seals.
9. Place address labels on the outside of the cooler.
10. Ship samples overnight by a commercial carrier such as FedEx.

2.3 PACKAGING HAZARDOUS SAMPLES

The procedures for packaging hazardous samples are summarized below. Note that according to the DGR, all spellings must be exactly as they appear in the List of Dangerous Goods, and only approved abbreviations are acceptable. The corresponding HMR regulations are provided in parentheses following any DGR referrals. The HMR must be followed only if shipping hazardous samples by ground transport.

1. Determine the proper shipping name for the material to be shipped. All proper shipping names are listed in column B of the List of Dangerous Goods table in Section 4 of the DGR (or column 2 of the Hazardous Materials Table in 49 CFR 172.101). In most instances, a generic name based on the hazard class of the material is appropriate. For example, a sample of an oily liquid collected from a drum with a high photoionization detector (PID) reading should be packaged as a flammable liquid. The proper shipping name chosen for this sample would be “flammable liquid, n.o.s.” The abbreviation “n.o.s.” stands for “not otherwise specified” and is used for generic shipping names. Typically, a specific name, such as acetone, should be inserted in parentheses after most n.o.s. descriptions. However, a technical name is not required when shipping a sample for testing purposes and the components are not known. If shipping a hazardous substance (see definition), then the letters “RQ” must appear in front of the proper shipping name.
2. Determine the United Nations (UN) identification number, class or division, subsidiary risk if any, required hazard labels, packing group, and either passenger aircraft or cargo aircraft packing instructions based on the quantity of material being shipped in one package. This information is provided in the List of Dangerous Goods (or Hazardous Materials Table in 49 CFR 172.101) under the appropriate proper shipping name. A “Y” in front of a packing instruction indicates a limited quantity packing instruction. If shipping dry ice or a limited quantity of a material, then UN specification shipping containers do not need to be used.
3. Determine the proper packaging required for shipping the samples. Except for limited quantity shipments and dry ice, these are UN specification packages that have been tested to meet the packing group of the material being shipped. Specific testing requirements of the packages is listed in Section 6 of the DGR (or 49 CFR 178 of the HMR). All UN packages are stamped with the appropriate UN specification marking. Prior planning is required to have the appropriate packages on hand during a sampling event where hazardous samples are anticipated. Most samples can be shipped in either a 4G fiberboard box, a 1A2 steel drum, or a 1H2 plastic drum. Drums can be purchased in 5- and 20-gallon sizes and are ideal for shipping multiple hazardous samples. When FedEx is used to ship samples containing PCBs, the samples must be shipped in an inner metal packaging (paint can) inside a 1A2 outer steel drum. This method of packaging PCB samples is in accordance with FedEx variation FX-06, listed in Section 2 of the DGR.

4. Place each sample jar in a separate resealable plastic bag. Some UN specification packagings contain the sample jar and plastic bag to be used when shipping the sample.
5. Place each sealed bag inside the approved UN specification container (or other appropriate container if a limited quantity or dry ice) and pack with enough noncombustible, absorbent, cushioning material (such as vermiculite) to prevent breakage and to absorb liquid.
6. Place chain-of-custody forms in a resealable plastic bag and either attach it to the inside lid of the container or place it on top inside the container. Place instructions for returning the container to the shipper on the inside lid of the container as appropriate. Close and seal the shipping container in the manner appropriate for the type of container being used.
7. Label and mark each package appropriately. All irrelevant markings and labels need to be removed or obliterated. All outer packagings must be marked with proper shipping name, UN identification number, and name and address of the shipper and the recipient. For carbon dioxide, solid (dry ice), the net weight of the dry ice within the package needs to be marked on the outer package. For limited quantity shipments, the words “limited quantity” or “LTD. QTY.” must be marked on the outer package. Affix the appropriate hazard label to the outer package. If the material being shipped contains a subsidiary hazard, then a subsidiary hazard label must also be affixed to the outer package. The subsidiary hazard label is identical to the primary hazard label except that the class or division number is not present. It is acceptable to obliterate the class or division marking on a primary hazard label and use it as the subsidiary hazard label. If using cargo aircraft only packing instructions, then the “Cargo Aircraft Only” label must be used. Package orientation labels (up arrows) must be placed on opposite sides of the outer package. Figure 1 depicts a properly marked and labeled package.
8. If using an overpack (see definition), mark and label the overpack and each outer packaging within the overpack as described in step 7. In addition, the statement “INNER PACKAGES COMPLY WITH PRESCRIBED SPECIFICATIONS” must be marked on the overpack.
9. Attach custody seals, and fill out the appropriate shipping papers as described in Section 2.4.

2.4 SHIPPING PAPERS FOR HAZARDOUS SAMPLES

A “Shippers Declaration for Dangerous Goods” and “Air Waybill” must be completed for each shipment of hazardous samples. FedEx supplies a Dangerous Goods Airbill to its customers; the airbill combines both

the declaration and the waybill. An example of a completed Dangerous Goods Airbill is depicted in Figure

2. A shipper's declaration must contain the following:

- Name and address of shipper and recipient
- Air waybill number (not applicable to the HMR)
- Page ____ of ____
- Deletion of either "Passenger and Cargo Aircraft" or "Cargo Aircraft Only," whichever does not apply
- Airport or city of departure
- Airport or city of destination
- Deletion of either "Non-Radioactive" or "Radioactive," which ever does not apply
- The nature and quantity of dangerous goods. This includes the following information in the following order (obtained from the List of Dangerous Goods in the DGR): proper shipping name, class or division number, UN identification number, packing group number, subsidiary risk, quantity in liters or kilograms (kg), type of packaging used, packing instructions, authorizations, and additional handling information. Authorizations include the words "limited quantity" or "LTD. QTY." if shipping a limited quantity, any special provision numbers listed in the List of Dangerous Goods in the DGR, and the variation "USG-14" when a technical name is required after the proper shipping name but not entered because it is unknown.
- Signature for the certification statement
- Name and title of signatory
- Place and date of signing certification
- A 24-hour emergency response telephone number for use in the event of an incident involving the dangerous good
- Emergency response information attached to the shipper's declaration. This information can be in the form of a material safety data sheet or the applicable North American Emergency Response Guidebook (NAERG; DOT 1996) pages. Figure 3 depicts the appropriate NAERG emergency response information for "Flammable liquids, n.o.s." as an example.

Note that dry ice does not require an attached shipper's declaration. However, the air waybill must include the following on it: "Dry ice, 9, UN1845, ____ x ____ kg." The blanks must include the number of packages and the quantity in kg in each package. If using FedEx to ship dry ice, the air waybill includes a box specifically for dry ice. Simply check the appropriate box and enter in the number of packages and quantity in each package.

The HMR requirements for shipping papers are located in 49 CFR 172 Subpart C.

3.0 POTENTIAL PROBLEMS

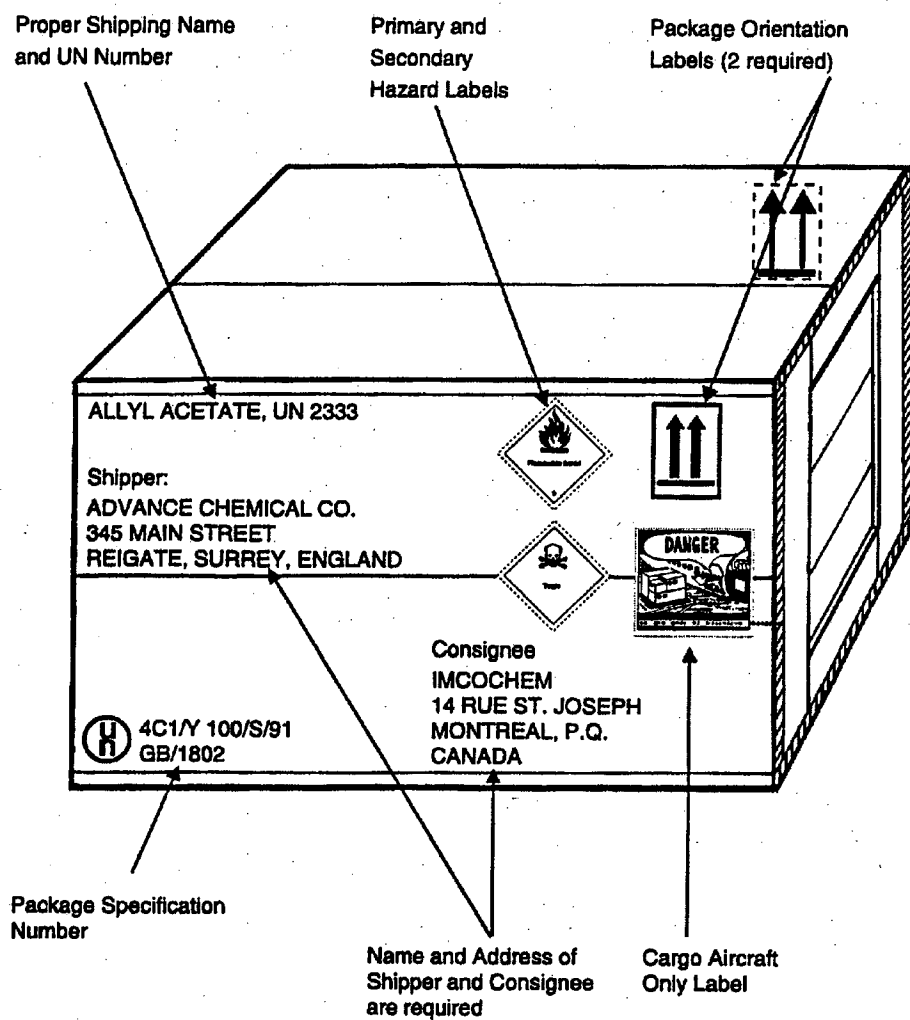
The following potential problems may occur during sample shipment:

- Leaking package. If a package leaks, the carrier may open the package, return the package, and if a dangerous good, inform the Federal Aviation Administration (FAA), which can result in fines.
- Improper labeling and marking of package. If mistakes are made in labeling and marking the package, the carrier will most likely notice the mistakes and return the package to the shipper, thus delaying sample shipment.
- Improper, misspelled, or missing information on the shipper's declaration. The carrier will most likely notice this as well and return the package to the shipper.

Contact FedEx with questions about dangerous goods shipments by calling 1-800-463-3339 and asking for a dangerous goods expert.

FIGURE 1

EXAMPLE OF A CORRECTLY MARKED AND LABELED DANGEROUS GOODS PACKAGE



Source: International Air Transport Association (IATA). 1997.

FIGURE 2

EXAMPLE OF A DANGEROUS GOODS AIRBILL

FedEx Dangerous Goods **Airbill** Sender's Copy
11729489 RETAIN THIS COPY FOR YOUR RECORDS

1 From Please print and press hard.
Date **FILL IN** Sender's FedEx Account Number **1788-8014-4**
Sender's Name **FILL IN** Phone **(312) 856 8700**

Company **TETRA TECH EN INC**
Address **200 E RANDOLPH ST STE 4700** Dept./Floor/Suite/Room
City **CHICAGO** State **IL** ZIP **60601**
Your Internal Billing Reference **FILL IN**
First 24 characters will appear on invoice.

3 To
Recipient's Name **FILL IN** Phone **()**
Company **FILL IN**
Address **FILL IN** We cannot deliver to P.O. boxes or P.O. ZIP codes. Dept./Floor/Suite/Room
City **FILL IN** State **FILL IN** ZIP **FILL IN**

For HOLD at FedEx Location check here
☐ Hold Weekday ☐ Hold Saturday
Available for FedEx Priority Overnight and FedEx 2Day to select ZIP codes.

For WEEKEND Delivery check here
☐ Saturday Delivery Available for FedEx Priority Overnight and FedEx 2Day to select ZIP codes.
☐ Sunday Delivery Available for FedEx Priority Overnight to select ZIP codes.

4a Express Package Service Packages up to 150 lbs.
☒ FedEx Priority Overnight Next business morning ☐ FedEx Standard Overnight Next business afternoon
☐ FedEx 2Day Second business day ☐ FedEx Express Saver Third business day

4b Express Freight Service Packages over 150 lbs.
☐ FedEx 1Day Freight* Next business day ☐ FedEx 2Day Freight Second business day ☐ FedEx 3Day Freight Third business day
* Call for Confirmation.

5 Packaging
☒ Other Packaging Dangerous Goods cannot be shipped in FedEx packaging.

6 Special Handling
☒ Dangerous Goods as per attached Shipper's Declaration ☐ Cargo Aircraft Only

7 Payment
Bill To: ☒ Sender ☐ Recipient ☐ Third Party ☐ Credit Card ☐ Cash Check
Enter FedEx Acct. No. or Credit Card No. below.
FedEx Account No. **FILL IN**
Credit Card No. **FILL IN** Exp. Date **FILL IN**

Total Packages **FILL IN** Total Weight **FILL IN** Total Declared Value \$ **00**

Signature Release Unavailable PART #154827 • Rev. Date 1/19/98 ©1994-98 FedEx • PRINTED IN U.S.A.

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Page 1 of 1 Pages

TRANSPORT DETAILS
This shipment is within the limitations prescribed for (delete non-applicable):
☒ PASSENGER AND CARGO AIRCRAFT ☒ CARGO AIRCRAFT ONLY
Airport of Departure: **Chicago**
Airport of Destination: **"City sending sample to"**

Shipment type: (delete non-applicable)
☒ NON-RADIOACTIVE ☐ RADIOACTIVE

NATURE AND QUANTITY OF DANGEROUS GOODS

Dangerous Goods Identification					Quantity and Type of Packaging	Packing Instr.	Authorization
Proper Shipping Name	Class or Division	UN or I.D. No.	Packing Group	Subsidiary Risk			
Flammable liquid, n.o.s.	3	UN 1993	III	—	4 glass jars in a 2A2 steel drum Net Quantity = 4L	309	A3 USG-14

Additional Handling Information: **NAERG# 128 Attached.**

Prepared for AIR TRANSPORT according to: (Customer MUST check one)
☐ 49 CFR ☒ ICAO / IATA

I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name and are classified, packaged, marked, and labeled/placarded, and are in all respects in proper condition for transport according to applicable international and national governmental regulations.

Emergency Telephone Number (Required for U.S. Origin or Destination Shipments) **FILL IN**

Name/Title of Signatory: **ME, Environmental Scientist**
Place and Date: **200 E Randolph, Chicago, IL 2/12/00**
Signature (non-removing sticker): **me**

IF ACCEPTABLE FOR PASSENGER AIRCRAFT THIS SHIPMENT CONTAINS RADIOACTIVE MATERIAL INTENDED FOR USE IN, OR INCIDENT TO, RESEARCH, MEDICAL DIAGNOSIS, OR TREATMENT.

FIGURE 3

NAERG EMERGENCY RESPONSE INFORMATION
FOR FLAMMABLE LIQUIDS, N.O.S.

GUIDE 128 HAZARDOUS LIQUIDS (Non-Polar/Water-Insoluble)	NAERG	NAERG	FLAMMABLE LIQUIDS (Non-Polar/Water-Insoluble)	GUIDE 128
POTENTIAL HAZARDS		EMERGENCY RESPONSE		
FIRE OR EXPLOSION		FIRE		
<ul style="list-style-type: none">• HIGHLY FLAMMABLE: Will be easily ignited by heat, sparks or flames.• Vapors may form explosive mixtures with air.• Vapors may travel to source of ignition and flash back.• Most vapors are heavier than air. They will spread along ground and collect in low or confined areas (sewers, basements, tanks).• Vapor explosion hazard indoors, outdoors or in sewers.• Some may polymerize (P) explosively when heated or involved in a fire.• Runoff to sewer may create fire or explosion hazard.• Containers may explode when heated.• Many liquids are lighter than water.• Substances may be transported hot.		<ul style="list-style-type: none">• CAUTION: All these products have a very low flash point. Use of water spray when fighting fire may be inefficient.• Small Fires<ul style="list-style-type: none">• Dry chemical, CO₂, water spray or regular foam.• Large Fires<ul style="list-style-type: none">• Water spray, fog or regular foam.• Do not use straight streams.• Move containers from fire area if you can do it without risk.• Fire Involving Tanks or Car/Trailer Loads<ul style="list-style-type: none">• Fight fire from maximum distance on one unmanned hose holder or monitor nozzle.• Cool containers with flooding quantities of water until well after fire is out.• Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank.• ALWAYS stay away from the ends of tanks.• For massive fire, use unmanned hose holders or monitor nozzles; if this is impossible, withdraw from area and let fire burn.		
HEALTH		SPILL OR LEAK		
<ul style="list-style-type: none">• Inhalation or contact with material may irritate or burn skin and eyes.• Fire may produce irritating, corrosive and/or toxic gases.• Vapors may cause dizziness or suffocation.• Runoff from fire control or dilution may cause pollution.		<ul style="list-style-type: none">• ELIMINATE all ignition sources (no smoking, flames, sparks or flames in immediate area).• All equipment used when handling the product must be grounded.• Do not touch or walk through spilled material.• Stop leak if you can do it without risk.• Prevent entry into sewers, storm, basements or confined areas.• A vapor suppressing foam may be used to reduce vapors.• Absorb or cover with dry earth, sand or other non-combustible material and transfer to containers.• Use clean non-sparking tools to collect absorbed material.		
PUBLIC SAFETY		Large Spills		
<ul style="list-style-type: none">• CALL Emergency Response Telephone Number on Shipping Paper first, if Shipping Paper not available or no answer, refer to appropriate telephone number listed on the inside back cover.• Isolate spill or leak area immediately for at least 25 to 50 meters (80 to 150 feet) in all directions.• Keep unauthorized personnel away.• Stay upwind.• Keep out of low areas.• Ventilate closed spaces before entering.		<ul style="list-style-type: none">• Take for disposal to a spill facility or disposal.• Water spray may reduce vapor; but may not prevent ignition in upper areas.		
PROTECTIVE CLOTHING		FIRST AID		
<ul style="list-style-type: none">• Wear positive pressure self-contained breathing apparatus (SCBA).• Structural firefighters' protective clothing will only provide limited protection.		<ul style="list-style-type: none">• Move victim to fresh air. Call emergency medical care.• Apply artificial respiration if victim is not breathing.• Administer oxygen if breathing is difficult.• Remove and isolate contaminated clothing and shoes.• In case of contact with substance, immediately flush skin or eyes with running water for at least 20 minutes.• Wash skin with soap and water.• Keep victim warm and quiet.• Ensure that medical personnel are aware of the material(s) involved and take precautions to protect themselves.		
EVAUATION				
Large Spill				
<ul style="list-style-type: none">• Consider initial downwind evacuation for at least 300 meters (1000 feet).				
Fire				
<ul style="list-style-type: none">• If tank, rail car or tank truck is involved in a fire, ISOLATE for HED (1/2 mile) in all directions, also, consider initial evacuation for 800 meters (1/2 mile) in all directions.				

Source: DOT and others. 1996.

SOP APPROVAL FORM

TETRA TECH EM INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

RECORDING OF NOTES IN FIELD LOGBOOK

SOP NO. 024

REVISION NO. 1

Last Reviewed: November 1999

R. Miesing

Quality Assurance Approved

May 18, 1993

Date

1.0 BACKGROUND

The field logbook should contain detailed records of all the field activities, interviews of people, and observations of conditions at a site. Entries should be described in as much detail as possible, so that personnel can accurately reconstruct the activities and events which have taken place during field assignments. Field logbooks are considered accountable documents in enforcement proceedings and may be subject to review. Therefore, the entries in the logbook must be accurate, detailed, and reflect the importance of the field events.

1.1 PURPOSE

The purpose of this standard operating procedure (SOP) is to provide guidance to ensure that logbook documentation for any field activity is correct, complete, and adequate. Logbooks are used for identifying, locating, labeling, and tracking samples. A logbook should document any deviations from the project approach, work plans, quality assurance project plans, health and safety plans, sampling plans, and any changes in project personnel. They also serve as documentation of any photographs taken during the course of the project. In addition, the data recorded in the logbook may assist in the interpretation of analytical results. A complete and accurate logbook also aids in maintaining good quality control. Quality control is enhanced by the proper documentation of all observations, activities, and decisions.

1.2 SCOPE

This SOP establishes the general requirements and procedures for recording notes in the field logbook.

1.3 DEFINITIONS

None

1.4 REFERENCES

Compton, R.R. 1985. *Geology in the Field*. John Wiley and Sons. New York, N.Y.

1.5 REQUIREMENTS AND RESOURCES

The following items are required for field notation:

- Field logbooks
- Ballpoint pens with permanent ink
- 6-inch ruler (optional)

Field logbooks should be bound (sewn) with water resistant and acid-proof covers; they should have preprinted lines and wide columns. They should be approximately 7 1/2 by 4 1/2 inches or 8 1/2 by 11 inches in size. Loose-leaf sheets are not acceptable for field notes. If notes are taken on loose paper, they must be transcribed as soon as possible into a regular field logbook by the same person who took the notes.

Logbooks can be obtained through the Document Control Administrator (DCA) for each office. The DCA will have assigned each logbook an identification number. The DCA will make sure the pages in the logbooks are preprinted with consecutive numbers or are consecutively numbered by hand. If the numbers are written by hand, then numbers should be circled so that they are not confused with data.

2.0 PROCEDURES

The following subsections provide general guidelines and formatting requirements for field logbooks and detailed procedures for completing field logbooks.

2.1 GENERAL GUIDELINES

- A separate field logbook must be maintained for each project. If a site consists of multiple subsites, designate a separate logbook for each subsite. For special tasks, such as periodic well water-level measurements, data from multiple subsites may be entered into one logbook which contains only one type of information.
- All logbooks must be bound and contain consecutively numbered pages.
- No pages can be removed from the logbook for any purpose.

- All field activities, meetings, photographs, and names of personnel must be recorded in the site logbook.
- All logbooks pertaining to a site or subsite should be assigned a serial number based on the date the logbook is issued to the project manager. The first logbook should be assigned number 1, the next logbook issued assigned number 2, and so on. The project manager is to maintain a record of all logbooks issued under the project.
- All information must be entered with a ballpoint pen with waterproof ink. Do not use pens with “wet ink,” because the ink may wash out if the paper gets wet. Pencils are not permissible for field notes because information can be erased. The entries should be written dark enough so that the logbook can be easily photocopied.
- Do not enter information in the logbook that is not related to the project. The language used in the logbook should be factual and objective.
- Begin a new page for each day’s notes.
- Write notes on every line of the logbook. If a subject changes and an additional blank space is necessary to make the new subject title standout, skip one line before beginning the new subject. Do not skip any pages or parts of pages unless a day’s activity ends in the middle of a page.
- Draw a diagonal line on any blank spaces of four lines or more to prevent unauthorized entries.

2.2 LOGBOOK FORMAT

The layout and organization of each field logbook should be consistent with other field logbooks. Guidelines for the cover, spine, and internal pagination are discussed below.

2.2.1 FORMAT OF FIELD LOGBOOK COVER AND SPINE

Write the following information in clear capital letters on the front cover of each logbook.

- Logbook identification number (assigned by the DCA)
- The serial number of the logbook (assigned by the project manager)
- Name of the site, city, and state

- Name of subsite if applicable
- Type of activity
- Beginning and ending dates of activities entered into the logbook
- "Tetra Tech EM Inc." City and State
- "REWARD IF FOUND"

Some of the information listed above, such as the list of activities and ending dates, should be entered after the entire logbook has been filled or after it has been decided that the remaining blank pages in the logbook will not be filled.

The spine of the logbook should contain an abbreviated version of the information on the cover. For example: "1, Col. Ave., Hastings, 5/88 - 8/88."

2.2.2 First Page of the Field Logbook

Spaces are usually provided on the inside front cover (or the opening page in some logbooks), for the company name ("Tetra Tech EM Inc."), address, and telephone number. If preprinted spaces for this information are not provided in the logbook, write the information on the first available page.

2.3 ENTERING INFORMATION IN THE LOGBOOK

Enter the following information at the beginning of each day or whenever warranted during the course of a day:

- Date
- Starting time
- Specific location
- General weather conditions and approximate temperature

- Names of personnel present at the site. Note the affiliation(s) and designation(s) of all personnel.
- Equipment calibration and equipment models used.
- Changes in instructions or activities at the site.
- Levels of personal protective clothing and equipment.
- A general title of the first task undertaken (for example, well installation at MW-11, decon at borehole BH-11, groundwater sampling at MW-11).
- Provide an approximate scale for all diagrams. If this can't be done, write "not to scale" on the diagram. Indicate the north direction on all maps and cross-sections. Label features on each diagram.
- Corrections should be made by drawing a single line through the entry being corrected. Initial and date any corrections made in the logbook.
- The person recording notes is to initial each page after the last entry. No information will be entered in the area following these initials.
- At the end of the day, the person recording notes is to sign and date the bottom of the last page. Indicate the end of the work day by writing "Left site at (time)." A diagonal line will be drawn across any blank space to the bottom of the page.

The following information should be recorded in the logbook after taking a photograph:

- Time, date, location, direction, and if appropriate, weather conditions
- Description of the subject photographed and the reason for taking the picture
- Sequential number of the photograph and the film roll number (if applicable)
- Name of the photographer

The following information should be entered into the logbook when taking samples:

- Location description
- Names of samplers
- Collection time
- Designation of samples as a grab or composite sample
- Type of sample (water, sediment, soil gas, etc.)

- On-site measurement data (pH, temperature, specific conductivity)
- Field observations (odors, colors, weather, etc.)
- Preliminary sample description
- Type of preservative used
- Instrument readings

2.4 PRECAUTIONS

Custody of field logbooks must be maintained at all times. Field personnel must keep the logbooks in a secure place (locked car, trailer, or field office) when the logbook is not in personal possession. Logbooks are official project documents and must be treated as such.

NOTE: The following wells were Plugged and Abandoned by EPA: MW-7; BC-31; MW-5; BC-01; BC-11; and BC-27

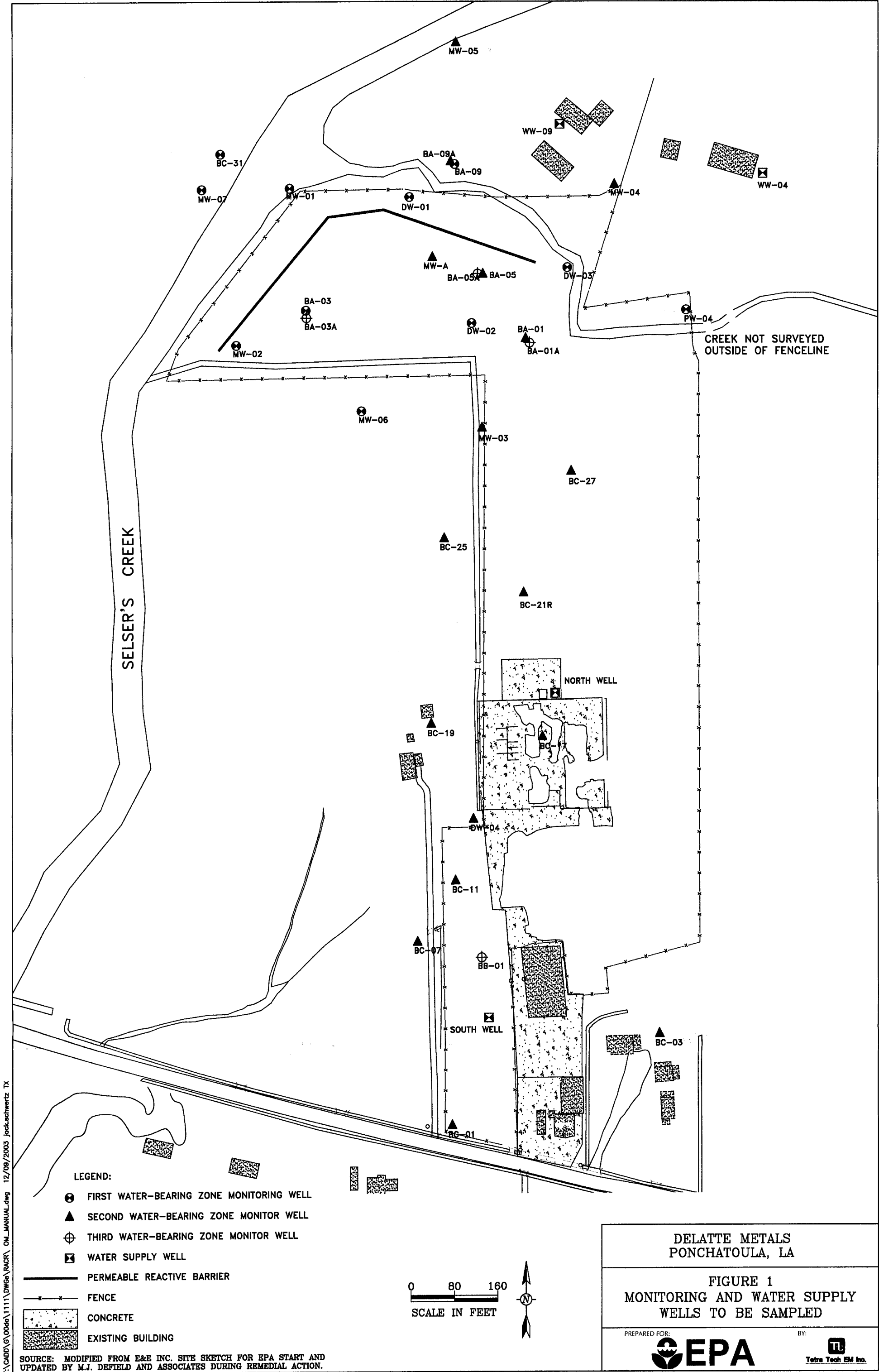
APPENDIX D

FIGURE

MONITORING AND WATER SUPPLY WELLS TO BE SAMPLED

(One Page)

NOTE: The following wells were Plugged and Abandoned by EPA: MW-7; BC-31; MW-5; BC-01; BC-11; and BC-27



APPENDIX E

TREND ANALYSIS FOR INTRAWELL COMPARISONS

(Six Pages)

TREND ANALYSIS FOR INTRAWELL COMPARISONS

Trend analysis is a statistical tool used to detect and evaluate temporal or spatial trends in a data set. Trend analysis is a useful way to evaluate changes within one well or sampling location. Preferably, any data set evaluated for trends over time will have at least eight time-independent observations and a minimum detection rate of 50 percent (EPA 2000). As the number of observations grows over time, so does the certainty of observed trends.

There are several different statistical tests that may be used for evaluating whether a trend exists, with a given probability. The Mann-Kendall test, the Kendall tau test, and Sen's Slope Estimator are appropriate nonparametric tests that are less sensitive to outliers than parametric regression methods. Regression control charts provide graphic depictions of trends and confidence intervals, but unlike the Mann-Kendall and Sen's Slope Estimator, regression control charts are parametric tests that assume a linear relationship between two variables. Regression-based methods focus mainly on monotonic, long-term trends and generally assume that individual observations can be ranked into two ordered series (for example, sampling dates and concentrations). Tests may give a value -- such as the Pearson product-moment correlation coefficient -- that indicates the strength of the correlation between the two variables.

Trend analysis can be used to evaluate whether the concentrations of a constituent within a single well have increased or decreased over a particular time period. Data will be evaluated in the O&M report to ascertain if contaminant concentrations in each well show statistically significant increases or decreases over time. The critical question for the Delatte site is, "Are concentrations of COCs in groundwater sampled at site and compliance wells increasing or decreasing over time, as shown by trends in concentrations at each well?" Several different methods that may be used to evaluate concentrations trends in the Delatte wells are described in the following sections.

Mann-Kendall Test for Trend

The Mann-Kendall test does not require that data be normally distributed. This test lists the data in temporal order and evaluates each pairwise slope of the time-ordered data. The test statistic is the difference between the number of positive and the number of negative differences. A negative value for

the test statistic indicates decreasing values over time, whereas a positive value for the test statistic indicates increasing values over time. The test statistic provides a measure of upward and downward trends, but the confidence in a trend is provided by the probability value (p-value) for the Mann-Kendall test, which indicates the confidence with which the null hypothesis may be rejected.

The null hypothesis for the Mann-Kendall test states that there is no temporal trend in the data values; therefore, the p-value provides the level of confidence for rejecting the null hypothesis. For example, a p-value of 0.01 indicates 99 percent confidence that a real trend exists. A p-value of 0.05 indicates 95 percent confidence that a real trend exists, a p-value 0.10 indicates 90 percent confidence that a real trend exists, and a p-value of 0.20 indicates 80 percent confidence that a real trend exists.

Sen's Slope Estimator

Sen's slope estimator is a nonparametric method for estimating a slope that computes slopes for all pairs of ordinal time points, then uses the median of these slopes as an estimate of the overall slope. Sen's slope estimator is the median of all the $n(n-1)/2$ pairwise slopes. This approach differs from linear regression analysis, which evaluates a "best fit" overall, based on least squares regression rather than calculating a slope between each data pair.

If there is no consistent upward or downward trend in the data pairs, Sen's would be a value near zero (any random upward or downward directions cancel out). If the underlying trend is downward, Sen's estimator is a negative value; if the underlying trend is upward, Sen's estimator is a positive value. The magnitude of Sen's estimate does not necessarily connote statistical significance, which is why other methods are used in conjunction with Sen's method.

Kendall Tau Test

Kendall's tau is a nonparametric measure of association based on the number of concordances and discordances in paired observations. Concordance occurs when paired observations vary together, and discordance occurs when paired observations vary differently. The Kendall tau test evaluates data for trends and produces a p-value that indicates the probability that the trend is "real" or due to chance alone. In this, the Kendall tau test differs from other trend tests that provide only the degree of fit to an

estimated trend line. The lower the Kendall tau p-value, the more likely the trend is “real” and that the arrangement of data points is not due to chance only. For example, if the p-value from the Kendall tau test is 0.0100, there is a high probability (99 percent) that the trend is real; that is, there is less than a one percent probability that the arrangement of data points is due to chance alone. Conversely, if the p-value is 0.7506, then there is a 75 percent probability that the arrangement of data points is due to chance alone. The sign of the z-values and tau values indicates whether the trend is increasing (positive values) or decreasing (negative values) over time.

Regression Control Charts

Regression-based methods focus mainly on monotonic, long-term trends and generally assume that individual observations can be ranked into two ordered series (for example, sampling dates and concentrations). Tests may give a value -- such as the Pearson product-moment correlation coefficient -- that indicates the strength of the correlation between the two variables.

The general idea of the regression control chart is that the control limits established in the regression control chart will allow detection of a change in the relationship between the two variables (here, sampling date versus concentration). Unlike nonparametric tests, the regression control chart contains a regression line that assumes and summarizes the linear relationship between the two variables of interest. The individual data points are also shown in the same graph. Around the regression line are confidence intervals within which a certain proportion (e.g., 95 percent) of samples may be expected to fall, at about two standard errors of the estimate of the regression line. Outliers in this plot may indicate samples where, for some reason, the common relationship between the two variables of interest does not hold. A 95 percent confidence interval is the range of concentrations that has a 95 percent probability for containing the true concentration on a given date. Control limits lie outside the confidence intervals at about three standard errors of the estimate of the regression line and are used to mark “extreme” values. These control limits may not appear on every graph because they may lie outside the boundaries of the graph.

COMPARISONS OF UPGRADIENT VERSUS DOWNGRAIENT WELLS

In general, statistical tests used to compare two populations can be defined as parametric and nonparametric. A parametric test assumes that the data are normally (or lognormally) distributed. The characteristics of a normal distribution are specifically defined (Gilbert 1987) and follow the familiar bell-shaped curve. A nonparametric test “does not depend for its validity on the data being drawn from a specific distribution” (Gilbert 1987) and is, therefore, a “distribution-free” technique. Nonparametric tests require fewer assumptions about the data sets than do parametric tests, although both types of tests require that data be collected as random and independent measurements. For both parametric and nonparametric tests, there are “one-sample” and “two-sample” tests.

Two-sample parametric tests include the two-sample t-test. Nonparametric tests include the Wilcoxon Rank Sum (WRS), the Quantile test, and the Slippage test. The WRS and the Gehan tests compare the median values of two data sets, whereas the Quantile and Slippage tests examine the data values in the upper portion of the distributions of the two data sets. The WRS and Quantile tests will be used for statistical comparisons of the site and background populations in this investigation. These two tests are complementary and evaluate different aspects of the populations. As described in EPA guidance (2000a), when the WRS test is “applied with the Quantile test, the combined tests are most powerful for detecting true differences between the two population distributions.”

Wilcoxon Rank Sum Test

The WRS test is conducted to test whether measurements from one population tend to be consistently larger than those from another population. This test is a nonparametric version of the two-sample Student’s t-test. The WRS test uses ranks instead of the actual data values and does not require the data sets to be normally (or lognormally) distributed; however, approximately equal variance is assumed. If both data sets are normally distributed and the number of data in both data sets is large, the WRS test is 95.5 percent as powerful as the traditional Student’s t-test. That is, it is 95.5 percent as likely that the WRS test will detect a difference between the data sets when a true difference exists. If one or both data sets are not normally distributed, the two-sample t-test can be less powerful than the WRS test. Slight additions to the standard WRS test allow adjustments for ties in rank and for smaller sample sizes.

Assumptions of the WRS test include the requirement that the data are random and independent. The WRS test also assumes that the two underlying distributions are similar in shape and dispersion; however, it is generally a robust test, in particular to the effect of outliers because ranks are used rather than the actual values. This use of ranks instead of actual values limits the influence of outliers because any given data point can be no more extreme than the first or last rank (EPA 2000). The WRS test may, however, produce misleading results if many data values are the same (ties in rank); therefore, the optional correction for ties in rank was specified in the computer output. The procedure and examples for conducting the WRS test are described in detail in published sources (Gilbert 1987;EPA 2000).

Procedures for the WRS test include calculation of the probability p of obtaining the test statistic by chance alone. If calculated p -values are less than a critical value for a given level of significance (for example, p less than 0.05), then it is concluded that the median concentration at the site is statistically greater than the median ambient concentration, and the chemical is identified as a COPC. If the Type I (“false positive” also called “false rejection”) error rate of the WRS test is set at 0.05, then if the calculated p is greater than or equal to 0.05, there is insufficient evidence to reject the null hypothesis that the true medians of the site and background data sets are equal; that is, there is insufficient evidence to conclude that the true median of the chemical concentration in site soil exceeds the true median of the concentration in background soil. The WRS test will be applied to only chemical constituents that had a rate of detection greater than 50 percent.

Quantile Test

If the distributions of the two data sets appears to be equivalent but there are unresolved questions about some site data in the upper percentiles of the distribution, the Quantile test may be applied to address this question. The Quantile test is used in conjunction with a test such as the WRS and is a nonparametric, two-population test that was developed for comparing the right-hand tails or upper quantiles of two distributions. The Quantile test can be used in cases where some proportion of large responses (rather than the entire distribution) of one population has shifted relative to a second population. The Quantile test is not as powerful as the WRS test when the distribution of site concentrations is shifted in its entirety to the right of the ambient distribution. However, the Quantile test is more powerful than the WRS test for detecting cases where only a small number of high-value measurements are present in the upper quantile of the site distribution. For this reason, EPA (2000) recommends that the Quantile test be used in conjunction with the WRS test. When they are applied together, these tests have higher power to

detect true differences between the distributions of two populations. The Quantile test may be applied to data sets with a greater proportion of nondetections than the WRS test, as long as the values included in the test are not high-value nondetections. The Quantile test can accommodate a fairly large percentage of nondetected values because it ignores the low end of the data distribution.

The Quantile test is easy to apply. It consists of examining the largest r measurements in the pooled (and ordered) site and ambient data sets and counting the number of r measurements that are from the site. If k or more of the r measurements are for the site, the Quantile test declares that the upper range of concentrations at the site is elevated relative to the ambient population. The H_0 addressed by the Quantile test is that $e < 0$ and $D/s < 0$, where e is the proportion of site measurements that have shifted to the right and D/s is the magnitude (in units of standard deviation, s) of the shift.

References

- EPA (2000) Guidance for Data Quality Assessment: Practical Methods for Data Analysis. EPA QA/G-9. EPA/600/R-96/084. July.
- Gilbert, R.O. (1987). Statistical Methods for Environmental Pollution Monitoring. Van Nostrand Reinhold, New York. 320 pp.